2008

County of Prince George, Virginia

Phase 2 Report

A Report Looking at Solutions to the Broadband Gap in Prince George County

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Table of Contents

Overview of the Project

The County engaged CCG Consulting, LLC. (CCG) to study issues associated with broadband. The Phase 1 Report from CCG concluded that the County has a serious broadband gap. There are a significant number of households that are still using dial-up service and who can't get broadband service. It seems unlikely that the commercial broadband providers, Verizon and Comcast, will be filling the broadband gap and bringing broadband to these parts of the County.

CCG's recommendation in Phase 1 was to look for possible solutions for the County to bring broadband to the parts of the County that need it. This report looks at the technologies used to deliver broadband. The report then makes a specific recommendation to use a combination of fiber and copper to bring broadband to the County. The report then looks at the financial feasibility of providing broadband service under both a retail and wholesale business plan. Finally, the report looks at ways to fund the project.

Findings

1. CCG analyzed the technologies available to solve the broadband gap in the County and determined that the County should build fiber to the County Business Park in order to bring large amounts of bandwidth to businesses there. The need for significant broadband would be particularly useful in the near future as Rolls Royce builds a plant there and well as for businesses associated with the expansion of Fort Lee. In the future broadband will be important to lure new businesses to the County.

2. CCG's recommendation is that the County builds a wireless network to bring broadband to the unserved residences in the County. The specific network recommended consists of a dual, redundant, licensed microwave backbone at three existing towers in the County. The network would use Wi-Fi / WiMax radios to serve residents. The recommended network has a carrier class backbone, meaning it is highly reliable, and carries enough bandwidth to provide for significant bandwidth to customers. The initial network design should be able to deliver at least 3 Mbps download speeds to customers and maybe more depending on the availability of cheap access to the Internet Backbone. The customer network would consist of a mini-mesh design such that customers who cannot directly see one of the three towers would be able to get signal bounced from another customer.

3. The network design also recommends that the County build a fiber to a point outside the County to acquire cheaper Internet Backbone. It appears there would be better access to the Internet in Petersburg. There is also the possibility of connecting south of the County to the Mid-Atlantic Broadband Cooperative.

4. CCG looked at various ownership structures that might be used to build and operate the broadband network as follows:

    a. Owned and operated by the County
    b. Owned and operated by a Cooperative

c. Owned and operated by a non-profit corporation
d. Owned by the County but service provided by one or more retail operators.
e. Built and operated by a commercial firm.

5. CCG created financial business plans that analyzed the various alternatives. The analysis produced the following findings:

   a. The best financial alternative is a scenario where one entity builds and operates the network. This entity could be the County, a Cooperative or a non-profit corporation. Assuming that such a business could get 3,500 customers (a number indicated by the Phase 1 survey), it would be profitable and be able to pay for financing and operating costs. The best of these alternatives from a financial basis is the County as operator, since this would give the business access to bond financing. However, there are probably ways to get a Cooperative or non-profit company financed.
   b. CCG looked at a scenario where the County would build the core backbone network and some retail provider would pay for the customer receivers (Wholesale Scenario 1). The financial analysis shows that it would be possible for both parties to break even on a cash basis. However, when considering that the retail provider must make a significant investment, CCG does not believe this is a realistic or viable option and that no partners would agree to pay for the customer equipment.
   c. CCG also looked at a scenario where the County would build all of the network components including the customer receivers and one or more service provider would lease the network to provide retail services (Wholesale Scenario 2). This scenario shows that such a business plan could generate enough cash for both parties to break even. However, if the retail partner(s) also provided voice services they probably could make enough money to make this attractive to them. The biggest downside to this scenario is that there is a potential conflict of goals when one company builds the network and takes all of the financial risk (the County) while another entity is responsible for sales to customers. Undertaking a wholesale business plan is very risky for the County in that there may not be enough sales to make bond payments. Some other wholesale partnerships in the country are suffering due to lack of customer sales. If the network is operated by the entity taking the risk, they are more highly motivated to make enough sales to meet financial obligations.

6. CCG performed a breakeven analysis of the various scenarios. Breakeven is defined as a scenario where the County generates enough cash to make bond payments and maintains a positive cash balance.

   - For the retail scenario where the County would provide service directly to customers, the business will achieve breakeven at 2,750 customers.
   - For wholesale scenario 1, where the County and the ISP both share in funding assets, there was no penetration scenario that would achieve breakeven for both parties.
   - For wholesale scenario 2 where the County would build the network and one or more retail providers would provide service, the breakeven for the County is

4,600 customers. However, the retail providers will want to have more than 5,000 customers in order to be reasonably profitable.

- The survey described in the Phase 1 report indicated the possibility of as many as 5,400 potential residential customers, which is more than is needed for financial success.

7. From a ***financial perspective***, CCG ranks the preference for an operating model as follows, from best to worst:

    a. The County builds and operates the network.

    The most profitable scenario is one where the County builds and operates the broadband network. CCG understand this is not the County's preference, and there are legal and regulatory barriers to be overcome in Virginia. However, from a pure financial perspective, this is the most attractive option. The County has a good reputation with citizens and would probably fare well in such a business. The biggest factor in making the County successful is the availability of bond financing.

    b. A Cooperative or non-profit corporation builds and operates the network.

    A Cooperative or non-profit ought to be able to succeed in the business assuming that financing terms that are nearly as good as bond financing can be found. It probably would require grants from the County and State as well as creative financing to make this work. However, the area is already very familiar with the idea of a cooperative and customers in the area would probably willingly join a new one.

    c. The County builds everything and finds one reliable partner.

    The biggest drawback with this scenario is to find a reliable partner. Under this scenario the County would be taking all of the risk by financing the network with bonds. It would be essential to find a partner that would stay for the long run and who would make enough sales to allow the County to meet bond payments. Finding such a partner is a tall task.

    d. The County builds everything and has an Open Access network

    As hard as it might be to find one good partner, it's possibly even harder to open the network to everyone. Under this scenario the County may not attract the needed solid anchor tenant if they know they have to compete with multiple service providers. To date no Open Access network has succeeded financially in the US.

Other options do not look feasible. For example, there does not appear to be enough potential profit to lure a commercial company into the County to build and operate the network.

Obviously there are considerations other than financial ones. Virginia law poses significant barriers to municipalities entering the telecom business. There are particularly difficult barriers for entering the cable television or telephone business. However, it appears that there are ways for the County to enter the business to only offer broadband.

One of the biggest obstacles to overcome for the County is that there is currently not a ‘champion’ within the County government, that is a person or department that is willing to tackle the hard job of building a network and lunching a business. Every successful municipality that has entered the broadband business started with a champion. This sort of project is not something that can be delegated down the line unless somebody is willing to step up and take the extraordinary effort needed to make this work.

8. There are ways to finance this venture. If the County undertakes the venture as the retail provider or as the builder of a wholesale network, then there are a number of different bond financing options. If this was to be done by a Cooperative or non-profit business, then there probably must be some grants to get such a business started. A Cooperative could take advantage of loans from the USDA that are nearly as good as bond financing, except that they require a 20% equity contribution. The equity contribution probably could be funded with grants and deposits from customers.

9. At this point the County has no ‘champion’, that is no strong local proponent within the County government who wants to take charge of bringing broadband to the County. If the County is to succeed in such a venture, it’s essential that one person or one group within the County government be given the specific authority and responsibility to take the steps needed to pursue a solution.

Next Steps

This study points out that there is a broadband gap in the County and recommends a solution to solve the broadband gap. However, the engineering done in this study is high-level and there are several steps the County ought to take before adopting this plan. The following proposed steps would allow the County to know with certainty that you have the right technical and business solution moving forward. These steps were not within the budget of the original study, but are important steps to take to know you will be successful should the County decide to launch a broadband network.

1. The study recommends that the County build a fiber in order to connect to cheaper bandwidth. Any County network will require affordable backbone bandwidth in order to provide affordable service to customers within the County. There does not appear to be any reasonably priced connection point to the Internet within the County today. The study suggested that the two options to consider are to build fiber either north to Petersburg, where there are several carriers, or south out of the County to meet the Mid-Atlantic Broadband Cooperative. The next step would be to determine the better of these two options for obtaining cheaper backbone bandwidth. This would involve locating and discussing prices with the carriers in Petersburg and negotiating a connection with the Mid-Atlantic Broadband Cooperative.

2. The study makes a specific set of recommendations for the placement of radios on existing antennae in the County. However, these antennae were picked based upon a general analysis of the density of potential customers in the County. Before making the sort of investment required by this study, a preferred next step would be to perform a wireless propagation study. Such a study would create a map for each proposed spectrum and show specifically how each spectrum would cover the County. These coverage maps would allow the County to pick the best antenna sites based upon customer coverage. Such maps would also identify parts of the County where supplying a wireless solution will be problematical.

3. We know the County would prefer to operate a wholesale network whereby some Internet Service Provider would serve customers and pay a fee back to the County to lease the wireless network. However, the study was unable to make any specific recommendations concerning possible partners since there seems to be no independent ISPs operating within the County today. However, there are such ISPs elsewhere in nearby Counties and in nearby states. If the County wishes to move forward with a partner, then a next logical step would be to issue and RFP seeking a data partner.

4. For any solution the County considers, either operating your own network or finding a partner, it is our recommendation to engage the services or a regulatory lawyer. Virginia law creates a number of barriers against municipal entry into the telecom business and the County ought to get expert help to make sure your plans avoid legal challenges.

I Last Mile Connectivity Solutions

This section will look at existing broadband technologies available today and also look at where those technologies may be headed in the future. Next this section will look specifically at the technologies that best fit Prince George.

A. Existing Broadband Technologies

Before looking at the specific best solution for Prince George County, this section will look at the various technologies available today for the last mile solution.

1. Fiber Technologies

The Technology. Fiber optic communications is different from any other data transmission method, in that it does not use electricity through a conductor to transmit information. Instead of electrical signals, modulated light is used to transmit data over long distances through an insulated glass fiber. Fiber optics is currently the most efficient long distance communications method because it provides much faster data transfer speeds when compared to traditional interconnection media such as copper wire. Fiber is clearly the best technology available today for transmitting data.

Following is a description of the fiber optic products that are available today:

SONET Point-to-Point and Ring Fiber. The traditional use for fiber has been in point-to-point applications using the SONET (Synchronous Optical Network) technology. Since fiber can be built in long runs and since the signal can be sent for a long distance without a repeater, fiber has become the preferred technology for sending signals for long distances. Sprint was the first company to complete a coast-to-coast fiber network, but today almost all telephone and cable TV long haul is done using fiber. This is the technology used by Verizon. With SONET technology bandwidth is delivered as a T1 (synchronous 1.55 Mbps) or multiples of T1s.

Ethernet Point-to-Point and Ring Fiber. Newer fiber electronics is based upon delivering native Ethernet. In this system bandwidth is not delivered in multiples of a T1 as listed above. Rather the entire fiber is one continuous data stream. With Ethernet technology there is more intelligence built into data routing. With SONET technology each piece of data is assigned to a specific T1 equivalent time slot. However, with Ethernet each piece of data has routing information built into the packet and thus all bits of data can use any part of the data pipe. Ethernet routing is what allows the Internet to work – packets of data contain the needed routing information regardless of what network they are carried on.

Ethernet routing is far more efficient and lower in cost than SONET based routing. With SONET, a T1 channel is dedicated to each transmission path, even if there is nothing being used on a given T1 at a given moment. With Ethernet all data bits are free to grab the first available space, and thus an Ethernet pipe can carry much more data than a T1-based path.

Another advantage of Ethernet systems over SONET is the relative cheapness of the electronics needed to interpret the signals. SONET equipment must be able to segregate signals into the equivalent T1s while Ethernet equipment needs merely understand and route the data. Ethernet routing has greatly reduced the cost of fiber optics terminal equipment and Ethernet routing is quickly becoming the standard form of data transmission.

<u>Fiber-to-the-Home (FTTH).</u>

Fiber-to-the-Home (FTTH) technology takes advantage of relatively cheap lasers that allow the delivery of significant bandwidth to multiple locations.

FTTH technology can be divided into two distinct technologies – active optical networks and passive optical networks. These two technologies use the fiber in very different ways.

The Active Optical Network (AON) dedicates a fiber from each user back to the electronics. This means each customer has a dedicated path to the electronics and does not share bandwidth directly with another customer in the neighborhood. An AON network has many more field lasers than a passive network since there is a 1 to 1 ratio between field lasers and customers.

In an AON network, everything is encoded as data between the electronics and the customer. This means all services must be digitized and delivered as an IP data stream to the user. The AON uses only 2 wavelengths on each fiber - one for transmittal of data to the users and one for transmittal of data from the users.

Since everything on an AON is data, the only possible video product is IPTV. IPTV delivers one channel at a time to customers as they request it. This is a different model than normal broadcast TV, where almost all channels are delivered to a customer all of the time. With IPTV, a customer must have a settop box for each TV that wants to receive its own channels.

The current vendors making Active Optical Network equipment includes Pannaway, World Wide Packets, Occam, and PacketFront.

The Passive Optical Network (PON) uses passive hardware to "split" the signals so that a single high-powered laser can be shared by up to 64 customers (more typically by 32 customers). This technology requires less fiber than an AON since many customers in a row share the same single fiber. In construction, one fiber is weaved through many houses.

PON technology uses bandwidth on the fiber differently than the AON. The PON electronics divides up the optical wavelengths on the fiber to allow 1 wavelength to transmit data and voice to the users, another wavelength to receive data and voice from the users and a third wavelength to transmit RF video (like normal broadcast CATV video) to the users over one fiber strand.

Because the PON can transmit video at the RF level, the PON has the option of delivering video as an analog (RF level) or digital (IPTV) signal. This means that a PON does not require a settop box to deliver analog cable TV. A PON also uses existing home wiring more easily since the signal is delivered and split on the outside of the home, rather than at the settop box. This gives easier access to existing telephone and cable wiring.

The current vendors for PON equipment include Alcatel, Motorola, Tellabs, Calix, Wave7 and AllOptic.

Within a PON network there are three additional options for delivering signal to customers – knows as BPON, GPON and EPON.

Early PON systems used BPON (Broadband Passive Optical Network) technology. This technology uses a form of signaling called ATM, which is based upon the T1 architecture such as used by the incumbent telephone companies. The use of ATM did not allow for the full utilization of the fiber's capabilities. In a BPON system there are separate segments of customer bandwidth assigned for voice, Cable TV and data. The biggest drawback of the BPON technology is that it used up transmission space sending empty data. For example, during a voice call, a BPON system would send an empty signal for those times when nobody is talking. Newer technologies are much more efficient.

Today passive optical networks use either EPON (Ethernet Passive Optical Network) or GPON (Gigabit Passive Optical Network) technologies. These technologies use native Ethernet signaling for the customer delivery path, meaning that the bandwidth to the customer can be used more efficiently. In a GPON or EPON system there is till two separate data streams – one for cable TV and a second for voice and data. If a BPON and an EPON system were to carry the same amount of total bandwidth, the EPON system would actually deliver much more practical bandwidth. At full capacity the EPON system could use every available bit of capacity while the BPON system would devote a lot of transmission time to sending empty data paths.

The major difference between the three technologies is the amount of data that is delivered. Following is a chart of the maximum amount of bandwidth that can be delivered to a node of houses (32 homes):

BPON - 622 Mbps downstream, 150 Mbps upstream
EPON - 1 Gbps downstream, 1 Gbps upstream

GPON - 2.4 Gbps downstream, 1.2 Gbps upstream

FTTH technology is expected to continue to grow in available bandwidth. The limiting factor is the development of cheaper lasers. Already in the lab are systems that will deliver a terabyte of download speed and such technology upgrades will be introduced as laser prices drop.

In the marketplace, many municipalities and Verizon are building FTTH networks. Verizon markets their residential fiber product as FiOS and they have built a fiber network past more than 5 million homes. However, Verizon does not seem to have plans to deploy FTTH technology to areas of low density like Prince George County, at least not in the foreseeable future. Verizon is taking full advantage of the technology and is supplying some of the highest speed and most affordable bandwidth in the nation over the FIOS systems. Verizon's current FIOS data products and prices are:

Up to 5 Mbps Download / 2 Mbps Upload	$ 39.95
Up to 15 Mbps Download / 2 Mbps Upload	$ 49.95
Up to 30 Mbps Download / 5 Mbps Upload	$199.95

Installation - Free

Bandwidth. The theoretically maximum bandwidth available on fiber is astronomical in the mega terabit range. In practical terms the amount of bandwidth that can be delivered over fiber depends on the lasers being used. Generally, the higher the bandwidth, the more expensive the laser. For residential customers, the real limitation on bandwidth is the chip sets in PCs. Very few PCs can accept a signal at a speed greater than 100 Mbps today. A few vendors now have FTTH chip sets that allow 200 Mbps deliver to the home.

SONET lasers are designed to deliver bandwidth in multiples of a T1. Again, SONET networks are the traditional networks deployed by TDS and other telephone companies. A T1 is a data path of 1.544 Mbps in both directions. Following are the amounts of bandwidth that can be transmitted over a single fiber pair using the proper SONET electronics.

T1	1.544 Mbps		
DS3	45 Mbps	28 T1s	28 T1s
OC3	155 Mbps	3 DS3s	84 T1s
OC12	622 Mbps	4 OC3s	336 T1s
OC48	2,488 Mbps	4 OC12s	1,344 T1s
OC192	9,953 Mbps	4 OC48s	5,376 T1s
DWDM	159,248 Mbps	16 OC192s	86,016 T1s

While no fiber is designed to deliver only a T1 or a DS3, there are standard lasers and electronics available that can deliver the other listed bandwidths today. As the chart shows, one fiber pair using DWDM can deliver the equivalent of 86,016 T1s over one pair of fiber (but at a huge cost).

There are also several standard Ethernet lasers that can be purchased today:

10-Base T	10 Mbps
100 Base T	100 Mbps
Gig Ethernet	1,000 Mbps
10 GIG	10,000 Mbps

In comparing these bandwidths to SONET bandwidths, once would think that a 10-Base T system would be the equivalent of roughly 6.5 T1s. However, since Ethernet is so much more efficient than SONET, in practical terms a 10-Base T system is equivalent to something closer to 20 T1s. An Ethernet system uses all of the available "space" on the laser to deliver data. SONET systems use a technique called Time Division Multiplexing (TDM). With TDM, much of the bandwidth is used to send empty signal. For example, during a telephone call, a TDM system transmits the entire signal when there is no talking. An Ethernet system delivers on the signal when there is sound.

FTTH technology today can deliver as much as 2.4 Gbps per data path using GPON technology (two separate data paths). Future laser improvements are expected to boost PON speeds tremendously and there are terabyte lasers being tested in labs today.

2. Copper (DSL)

The Technology. Verizon and other telephone companies historically have deployed copper technology. With copper technology each customer is served either by copper entirely between the customer and the telephone company office, or by some combination of copper and fiber. In all cases the speeds that can be delivered to customers is limited by the copper portion of the network. Telephone companies sometimes build fiber directly to large business customers. To date, there appears to be little or no Verizon fiber built directly to customers in Prince George.

Verizon and other telephone companies deploy a technology called DSL (Digital Subscriber Line) to achieve greater bandwidth out of copper. DSL works by utilizing a different portion of the copper than is used to make normal telephone calls.

There are a number of different types of DSL in use. These are often referred to as the various "flavors" of DSL. They are typically marketed under the acronyms ADSL, ADSL2+, SDSL, HDSL, VDSL, IDSL and G-Lite. The following is a brief description of each of these types of DSL.

Deploying DSL is capital intensive for the service provider. The DSL network begins at a telephone company central office with a transmission device referred to as a DSL Access Multiplexer ("DSLAM"). A DSLAM is, in essence, a small data switch that can support multiple DSL users. Each customer must also have appropriate hardware to receive DSL. Most brands of DSL use a DSL modem at the customer location that is referred to as an IAD (Integrated Access Device). DSL also requires that the relevant copper be stripped of all signals other than the DSL signal. In the telephone industry, this is referred to as "deloading the line." The copper in the telephone system often was built using a system of power boosters and signal repeaters that allow the normal telephone signal to be carried with greater strength and for greater distances. In order to deploy DSL, such repeaters and boosters must be physically disconnected from the copper pair, and this usually requires a field crew with bucket trucks to trace the pair and to physically strip the copper pair.

The hardware cost of deploying DSL varies widely by brand purchased and by the specific flavor of DSL being deployed. G-Lite can now be purchased for as little as $250 per customer for both ends of the hardware. Some of the variations of ADSL and VDSL can cost as much $800 per customer. In any case, the telephone company must make a significant investment to deploy DSL. In addition, most flavors of DSL require customers to buy Ethernet modems for their computers – something most computers are now equipped with.

DSL is not readily available everywhere for a number of reasons. First, DSL is subject to distance limitations. DSL can reasonably be served up to 18,000 feet from a central office switch in the most favorable conditions, but poor copper wiring in most exchanges realistically makes this limit closer to 10,000 to 12,000 feet, depending on the brand of equipment. This distance limitation is further shortened in reality, since it is measured in cable feet rather than "as the crow flies" in a straight line. The copper wiring coming out of a central office often wanders up and down streets and rarely runs in a straight line to reach areas away from the switch. Realistically, in many exchanges, this 10,000 to 12,000 foot distance limitation creates a potential delivery circle of only about a mile-and-one-half around the switch.

There are two solutions to DSL's distance limitations. First, as newer generations of DSLAMs are developed to deliver higher bandwidths, the DSL delivery range will increase. DSL bandwidth delivery over copper is not linear, meaning that the amount of bandwidth that can be delivered drops off quickly with distance from the transmission point. Where a 1-Meg modem today might fall off to a 128k signal at 10,000 feet, a future 5-Meg modem might be able to deliver 1 Meg at that same distance. Thus, over time, the distance issue might be overcome to some degree through improved technology.

The second solution to DSL distance limitations results from what are referred to as "remote" or "mini" DSLAMs. This technology allows DSLAMs, or central

DSL hubs, to be moved into more remote locations in the network – e.g., to the cable junction in front of a housing development or a business park. From this remote DSL origination point, the DSL signal could still be delivered for the same distance, but this distance is now measured from the new field-installed hardware and not from the central office. Such technology should mean that DSL can be made available to most customers, but as will be described elsewhere in this paper, TDS seems to be deploying DSLAMs in all of its remote terminal locations in Monticello.

The second problem with DSL delivery is the existing copper network. Copper plant was not originally built with DSL in mind, and there are many places in current networks where DSL will not work, regardless of the distance from the central office. In some cases, the copper is too small in gauge or thickness, since the thicker the copper the better that DSL will work. In other cases, there are signal leaks into the system or there are other reasons why some copper pairs will not readily accept DSL signals. There is very little that can be done to fix stray "noise" problems, other than to replace the portions of the network that have such problems. Replacement is an expensive solution that often means re-wiring an entire neighborhood.

Third, DSL is a copper-only technology. This means that if any path to a customer includes even one foot of non-copper cable, such as fiber, then DSL will not function. For many years, Verizon and other telephone companies have been building new feeder cables using fiber. Feeder cables are large capacity cables that carry signals from the central office to large neighborhood clusters of homes and businesses. Fiber is cheaper and more reliable for this use, and almost all new subdivisions and business parks built in the last ten years are fed with fiber feeder cables. Additionally, phone companies have been replacing older copper feeder cables with fiber cables as they do routine upgrades. This has led to the strange phenomenon that the newer the neighborhood, the less likely that DSL will be available. Older neighborhoods that are built throughout with copper may be good candidates for DSL, whereas in newer areas with fiber feeds, DSL will not work without field deployment of the DSLAMs, a more costly way to provide service. This phenomenon is not favorable to rapidly growing communities in which a large percentage of homes and businesses have been built in the last ten years.

Bandwidth. A bare copper wire is limited, without enhancement to delivering 64 Kbps of information for voice. However, when delivering data some of this path must be used for signal overheads, and a bare copper wire is limited to delivering 56 Kbps of data. This is the fastest speed that can be achieved by dial-up Internet service.

In order to achieve higher data speeds over copper, telephone companies use one of two technologies. First, they can deliver a T1 to customers if they use two copper pairs. A T1 is 1.544 Mbps, or 24 times faster than dial-up Internet. A T1 is also a synchronous 2-way data path meaning that it can download and upload data at the same 1.544 Mbps speed. The problem with T1 service is generally an issue of cost. T1s require a fairly expensive piece of equipment at the end to receive the signal. T1s also require two copper pairs (or paying for two lines). T1s can generally be delivered to almost any customer. However, a T1 connected to the Internet can cost between $600 to $700 dollars per month in Prince George.

The second bandwidth product is DSL. Various DSL products offer different bandwidths. Following are some examples of the bandwidth available through each type of DSL:

ADSL	Up to 2 Mbps downstream, small upstream
ADSL2+	Up to 12 Mbps downstream, small upstream
Paired ADSL2+	Up to 24 Mbps downstream, small upstream
SDSL	Synchronous 2 Mbps
HDSL	Synchronous 1.544 Mbps (Same as a T1)
VDSL	12 Mbps for 3,000 feet. 6 Mbps to 6,000 ft.
IDSL	Synchronous 128k
G-Lite	2 Mbps downstream, small upstream

Problems and Issues with Copper. There are a number of problems with copper facilities that create problems for customers:

- In older neighborhoods the copper is also probably old. Older copper develops problems. Water can leak into the sheath. The copper wiring can degrade from age and weather. Generally older copper can't transmit as much data as newer copper.
- Different sizes of copper wires. Many residential neighborhoods were built with relatively thin copper wires. The thinner the wire the less data that can be carried. A DSL signal will travel farther over a 22-gauge copper wire than it will over a 24-guage copper wire (22-gauge being larger).
- Electrical Interference. Copper wire is subject to interference from electrical signals of all sorts, and this interference can cause problems with the signal.
- Repeaters. Copper is only capable of delivering a signal up to a few miles without the need for signal repeaters. Repeaters are electronic devices installed on the telephone lines that repeat and boost the signal. The repeaters generally interfere with DSL signals, and this is one of the factors that limit how far DSL can travel. In order to get DSL to work, a technician must climb poles and disconnect the repeaters for a DSL pair – a costly process.
- Inherent DSL distance limitations. DSL signals degrade with distance. Today, from a practical basis, a telephone company can't offer DSL for any customer more than 18,000 feet from the DSL transmitter. This distance represents physical feet of copper, not distance as the crow flies. Thus, customers within roughly a 3-mile circle around any telephone central office might be able to get DSL (depending on the other problems listed). Customers outside of these circles generally cannot get DSL. Another distance-related issue with DSL is that customers close to a telephone central office get more bandwidth than a

customer who is further away. A customer who lives 1 mile from a central office can get much better DSL bandwidth than a customer living 3 miles away.

- Different download and upload speeds. DSL is almost always configured to have a much higher download speed than an upload speed. Lower upload speeds limit the value of DSL for business customers and telecommuters. Uploading files will become a bottleneck for anybody trying to work at home or in an office with these limitations. The upload speeds are often drastically lower than the download speeds and it is not unusual to see a 2 Mbps download speed paired with a 256 Kbps upload speed (one tenth of the speed of the download).

3. Hybrid Fiber Coaxial Systems (HFC) – Cable Modems.

The Technology. Comcast deploys HFC coaxial cable technology in Prince George. HFC networks are bi-directional RF distribution systems capable of transmitting from 550 to 1,000 MHz of bandwidth. This technology, deployed by most cable operators and some telephone companies is an evolution of the traditional cable distribution networks, thereby inheriting the term "Hybrid".

Cable systems were originally designed to deliver through sealed coaxial cable lines the same radio-frequency signals that residents with good reception could obtain from television broadcast towers over the air. Over the years, cable operators have upgraded their networks to Hybrid Fiber Coaxial (HFC) systems by replacing some of their coaxial cables and associated facilities with fiber optic lines. They have also increased the bandwidth capacities of their systems from 330-450 MHz to 750-860 MHz (or more), adopted digital compression technologies, and added infrastructure to support Internet networking. As a result, a growing number of cable systems have the capacity to provide hundreds of television and music channels as well as high-speed Internet access. Many cable systems are now also providing or experimenting with telephone service.

Cable systems that provide cable modem service generally use one cable television channel (6MHz) for downstream signals and another channel for upstream signals. At the cable company headend, a cable modem termination system (CMTS) uses these channels to create a virtual local area network with cable modems attached to computers at subscriber residences. Depending on the transmission technology used, cable operators can theoretically send up to 36 Mbps per channel downstream from the cable headend, and users can send up to 10 Mbps per channel upstream. This upstream and downstream bandwidth must, however, be shared by all active users connected to a network segment called a "node." The level of usage at a node at any point in time can have a significant effect on the performance that individual users experience, as downstream speeds can drop from 1.5 Kbps to 500 Kbps or less as the number of simultaneous users increases. Upstream capacity is even more limited, as cable operators typically do not allocate as many channels for upstream use as they do for downstream use. In fact, some cable providers limit users to upstream speeds of 128 Kbps.

If congestion occurs because of high usage, cable operators can add additional channels or run fiber-optic lines deeper into neighborhoods, reducing the number of users per node. Years ago, cable systems often served up to 2,000 – 5,000 homes per node. That number has decreased significantly, with new systems generally designed to serve 500-1,000 homes per node.

Currently, cable modem service is not a viable option for many, if not most, businesses. For one thing, cable service is not generally available in commercial areas. This is in large part a historical phenomenon – cable operators typically did not build their systems out to commercial areas because few, if any, businesses subscribed to cable television service. Most cable companies would now be willing to extend their systems to commercial establishments if they could solve an even more significant problem – cable systems do not currently have the bandwidth or the expertise to support widespread business usage of their systems. For example, businesses typically cannot obtain web hosting services from cable companies. This may change over time, but it is not likely to change in the near future.

Cable systems are capable of delivering significant amounts of bandwidth to customers. However, what we see in the marketplace is that cable providers seem to have the goal of just staying ahead of DSL in capability. Most cable providers are very leery about dedicating too many channels for data service unless they have to – they would rather keep the channels for TV programming. Cable providers are wresting today with the desire to carry High Definition TV channels (HDTV) since these channels require much more bandwidth than traditional channels.

The cable TV providers have all banded together nationwide and created a firm that they all use to do research and product development – called Cable Labs. Cable Labs develops the specifications for cable modems and all of the cable providers have agreed to only use products that are Cable Labs compliant. Through this process the cable providers have been able to really get low prices for such things as cable modems and settop boxes.

Cable providers are not going to introduce products to their network that do not use Cable Labs standards and approved equipment. Thus, if some cable provider wanted to offer a 50 Mbps cable modem product they would be unable to find equipment. The industry sticks together and they will advance as a group.

With that said, competition will drive Cable Labs and the providers to develop faster cable modem products. For example, Verizon is currently offering a baseline 10 Mbps product on its FiOS Fiber-to-the-Home network for residential customers. Mediacom responded by rolling out a 15 MBPS cable modem (but only in those areas that are competing with Verizon's FIOS service). In general, cable companies could offer greater amounts of bandwidth, but economics, tight bandwidth for HDTV and a commitment to Cable Labs means we won't see great breakthroughs in cable modem speeds unless the market demands it.

Bandwidth. Coaxial cable systems can deliver much more bandwidth than copper systems. This is mainly due to the much larger size of the wire being used.

The amount of total bandwidth available in any HFC system is dependent upon the electronics of the system. Generally only a discrete amount of bandwidth is carved out of an HFC system for data delivery, with the remaining bandwidth used for cable TV channels. Today cable modem systems typically deliver up to 3 Mbps for data. Some metropolitan systems have been upgraded to deliver as much as 6 Mbps (although much of the 6 Mbps product is more hype than speed). In metropolitan New York City, Cablevision has launched a 15 Mbps modem in order to compete with Verizon GTTH. One feature inherent in an HFC system is that upload speeds are generally far slower than download speeds. This is due to the electronics used in the system and cannot be changed today.

However, one has to always be cautious when looking at data speeds on HFC systems since data is shared among many households. When the cable company advertises a speed of 3 Mbps, this represents the ***maximum*** speed that a customer can receive. The maximum speed generally can only be obtained at off-peak hours, like the middle of the night. During the day and evening when there are many customers sharing the network the speeds often get much slower. There are many reports nationwide of cable modem systems that slow down to dial-up speeds during peak evening usage.

Problems and Issues with Coaxial Cable. There are a number of problems with HFC systems as follows:

- Age of the wire. Just as with the telephone system, old degraded wiring will degrade the signal.
- Interference. Coaxial systems are extremely susceptible to interference from electrical sources. Interference can be seen on the TV signal as snow or noise. Coaxial connections are susceptible to interference at each place where there is a physical connection. In many houses there are many connections and thus many opportunities for the introduction of noise. A coaxial system with one or more open ports acts as a large antenna that can introduce interference into entire system. Noise in your house affects all of your neighbors.
- Shared nature of the System. HFC systems architecture is by nodes, meaning some fixed number of households in a neighborhood share the same local network. This means that that all customers in a node share the bandwidth for the node. Customers also share in noise and interference problems, and a problem with one customer usually affects other customers in the node. Shared bandwidth means that the amount of data available over a cable

modem will vary according to how many customers in a node are using the data system. It is not untypical for a cable modem system to bog down at peak hours as many customers are trying to use the shared bandwidth.

4. Unlicensed Wireless (Wi-Fi)

The Technology. Wi-Fi is short for ***wi**reless* ***fi**delity* and is meant to be used generically when referring of any type of 802.11 network**,** whether 802.11a, 802.11b or 802.11g. Any products tested and approved as "Wi-Fi Certified" (a registered trademark) by the Wi-Fi Alliance are certified as interoperable with each other, even if they are from different manufacturers. A user with a "Wi-Fi Certified" product can use any brand of access point with any other brand of client hardware that also is certified. Typically, however, any Wi-Fi product using the same radio frequency (for example, 2.4GHz for 802.11b or 802.11g, or 5.7 GHz for 802.11a) will work with any other, even if not "Wi-Fi Certified."

Wi-Fi is sold in the marketplace in several applications. Bluetooth is a Wi-Fi application that is meant for very short connections. Generally Bluetooth is used to connect devices together within a network, within the same building or room. Bluetooth is used for such devices as wireless keyboards, wireless mice and smart appliances. Bluetooth speeds are relatively slow at around 720 Kbps.

More common is wireless networking. With 802.11b Wi-Fi can deliver up to 11 Mbps for distances up to 300 feet. With 802.11g Wi-Fi can deliver up to 54 Mbps up to 150 feet. Both of these applications are used to create wireless LANs inside businesses and residences.

Another use of Wi-Fi is for public hotspots. Many cities have deployed wireless hotspots in key public locations like City hall or libraries. Wi-Fi hot spots can deliver relatively low bandwidth, typically less than 1 Mbps to laptops and handheld devices within a relatively short distance, usually no more than 600 feet with a full signal, or up to half a mile for a greatly diminished signal.

The final technology using Wi-Fi is deployment of outdoor networks. The Wi-Fi spectrum can be used to connect a central transmitter to multiple locations. There are three general network architectures that can be deployed with Wi-Fi today:

- Point-to-Point Connections. A point-to-point connection can be used to connect only two locations. This is a very expensive way to provide Internet connections and this technology is generally used more as part of a network as an alternative to fiber.
- Point-to-Multipoint systems. This technology allows one transmitter, generally mounted on a tall antenna, to deliver bandwidth to many locations. The limiting factor with point-to-multipoint systems is that the receiver must be within the line of sight of the transmitter. In areas like Monticello this kind of system has problems with trees and foliage.

- Mesh Network. This newest Wi-Fi technology is a point-to-multipoint technology with a twist. Each receiver at a customer location can be used in a mesh network to retransmit data to other customers. This solves the line of sight problem in that a customer does not need to see the base station transmitter as long as they can see one of more other customers on the network. However, mesh networks can't retransmit data forever and in the perfect network no customer would be more than 3 hops away from the base station transmitter.

Bandwidth. The amount of bandwidth that can be delivered using Wi-Fi depends on the specific vendor and depends even more on the backhaul network that feeds the wireless network. On a point-to-point basis (between only two points) Wi-Fi can deliver up to 17 Mbps. In a point-to-multipoint system there is generally a shared 17 Mbps that can be divided up among the customers hanging from a given antenna (or sector of an antenna). Wi-Fi networks are generally shared bandwidth meaning that all of the customers within a given access point share whatever data is available.

On a commercial basis, a Wi-Fi network can be designed to deliver a fairly high amount of bandwidth to a few customers or a modest amount of bandwidth to many customers. The typical Wi-Fi deployment delivers DSWL-like speeds.

5. Licensed Wireless Spectrum

There are three primary spectrums in use to deliver wireless broadband over licensed spectrum - Local Multipoint Distribution Service (LMDS), Multichannel Multipoint Distribution Service (MMDS) and wireless loops using Personal Communications Service (PCS). Each has certain advantages and disadvantages.

<u>LMDS</u>

LMDS is a broadband wireless point-to-multipoint system operating between 27.5 GHz to 31.3 GHz that can be used to provide digital two-way voice, data, Internet, and video services. With current equipment, this is primarily a delivery mechanism for large business customers because of the relatively high price of customer premises equipment (CPE) associated with the bandwidth. However, we believe that current Wi-Fi gear is going to be migrated into this bandwidth, and several large players are now investing in this bandwidth.

The LMDS spectrum is robust because of the 1150 MHz of bandwidth available with an A license. There is also an LMDS B spectrum license for every US market with 150 MHz of bandwidth. The spectrum is interesting in that it can be used for both a point-to-point delivery signal like traditional microwave systems and can also be used on a point-to-multipoint basis to serve large numbers of customers from one central transmitter. With the structure of the spectrum, a provider could deliver as much as DS3 (45 Mbps) of data to a customer through the air.

On the negative side there are several transmission characteristics that limit the use of LMDS. The most significant of these is the practical delivery distance of the signal, and the distance decreases with greater bandwidth and also decreases due to humidity and bad weather. In dry parts of the country, such as the desert west, LMDS can deliver bandwidth for 3 - 4 miles from a central transmitter. In humid, rainy places like Florida, the maximum distance could be as short as 1.5 miles. LMDS also has limitations due to foliage and obstructions, and a clear delivery path must be available for its use.

The FCC auctioned this spectrum more than seven years ago, but there are only a handful of systems that are operational today. In classic chicken-egg fashion, the CPE is expensive because there have not been many installations, and there have not been many installations because the CPE is expensive. Small investors own many LMDS licenses and until recently there has been no large nationwide providers pushing the development of equipment to utilize this spectrum.

MMDS

Another useful spectrum for data delivery is MMDS. This frequency, from 2.15 GHz to 2.68 GHz, was auctioned years ago and was originally intended for delivering wireless Cable TV. This did not materialize because the equipment took many years to develop, and more importantly because the cable TV industry evolved. MMDS systems can deliver approximately 30 channels of cable TV, which is no longer economically viable for cable TV in most markets.

In 1999 the FCC changed the rules for the spectrum by allowing it to be used for 2-way communications, thus opening it up for data and voice providers. Compared to LMDS, MMDS offers a solution for small and medium customers. With current CPE, it can deliver several megabytes of data along with voice lines on one small antenna. There are a few manufacturers of CPE that can currently deliver a customer antenna for under $1,500. At this price, this is a good solution for small business customers and maybe also for very high-end residential customers.

At one time there were high hopes for this spectrum. Licenses covering about 2/3 of the US population have been purchased by Sprint and MCI, and both companies announced aggressive plans to roll out MMDS beginning in early 2001. Both companies stopped the rollout in 2001 and there has been very little activity since then with this spectrum.

Wireless Using PCS Spectrum

Another wireless data technology is wireless using the PCS spectrum. The PCS spectrum is most normally used for delivering typical cell phone service, and the big license holders are companies like Sprint, Verizon and AT&T Wireless. Each of these providers is now starting to deliver data to customers in most urban markets. For example, the Verizon data product is marketed under the name of EVDO. There are several issues with PCS data delivery. First, the amount of data from a given cell site is dependent upon the amount of voice traffic. Voice for cell phones is given priority, and during peak times the amount of bandwidth available for data gets greatly diminished. Second, PCS data is never going to be very fast. A typical urban deployment is looking at peak speeds of around 750 Kbps downstream, very tiny upstream. This bandwidth is mostly being targeted to add enhancements to cell phone service to let customers read emails and get simple graphics. Data on this bandwidth is not intended as a DSL replacement. Most cell providers charge a lot for the service with typical prices for full-time access at around $80 per month.

In rural areas some providers are using PCS spectrum to deliver “fixed wireless”, a service that delivers both voice and data to homes with fixed antennas. Because such markets are rural, the amount of bandwidth is greater, as much as 2 Mbps. The data is also enhanced because of a powerful antenna installed at each customer’s location. The largest provider of fixed wireless loops is Western Wireless. This technology is used much more extensively in the rest of the world, and the largest single use is in Japan and sold under the name Handiphone.

6. Broadband over Powerline (BPL)

Broadband over Powerline (BPL) technology is a method of transmitting data over electric lines. BPL is currently widely deployed in Europe. However, the electric systems in the US use different protocols and standards, and the European product is more robust than the US one.

BPL is being considered as a direct competitor to DSL; however, early versions of BPL don’t deliver more than 1 Mbps. Expectations are that BPL will be improved and within a few years be capable of delivering as much as 10 Mbps.

The big promise for BPL is as a tool to deliver bandwidth to those customers without other data alternatives. Cable modems and DSL are primarily deployed in urban and suburban areas and there are many rural areas without any high bandwidth options. BPL has some distance limitations, but it can deliver a data signal much further than DSL. Electric companies, particularly rural electric companies are considering BPL. It will require some reengineering of existing power lines, but overall BPL systems require modest investments per customer, since the electric companies already own all of the lines and the right-of-ways to customers.

The only logical providers of BPL are electric companies since nobody else has access to electric lines.

7. Satellite Data

There is a general opinion among wireline carriers that satellite broadband as an access technology is inferior to other sources of Ethernet. The perception is that satellite broadband has serious latency problems (time delays) and jitter issues which make it inadequate to support advanced applications, particularly VoIP. There is also a general perception that satellite Ethernet is costly to establish and that it is rarely price competitive with other sources of Ethernet, except in very remote locations.

To some degree these observations still apply to much of the satellite industry. This industry has been historically focused on serving only very large backbone transport for carriers in very remote locations or the video broadcast industry where more than of 70% of their revenue is still derived on an annual basis. The major vendors of satellite data have been very slow to react to the general explosion of Ethernet in the world and they have not seized upon more mainstream opportunities in the landline world. To some degree we can compare the large satellite data providers to the large telephone companies – they are large incumbents who are satisfied with their market niche and not particularly open to change. Their behavior is geared towards selling wholesale transponder space as opposed to delivering value-added network services.

The satellite industry has historically been controlled by a handful of very large providers who both own and operate satellites or who have contracted for much of the usage on satellites. Companies like Hughes and Spacenet have created very stable businesses by selling large data pipes to remote locations. The customers for such data tend to be governments and large businesses that have large data needs in remote locations. These data connections have always been expensive compared to normal terrestrial data prices, but the remoteness of the sites has given the satellite providers a virtual monopoly of service. The hardware for satellite data delivery has historically been very expensive and most satellite data users typically purchased large amounts of bandwidth at a given site.

Residential and Small Business Data over Satellite

In recent years a number of companies have started selling satellite data to the residential market. These connections generally offer less speed at a greater price than cable modem and DSL connections. However, the fact that satellite data is available almost everywhere means that remote customers often find satellite as their only alternative. In the Monticello survey, one customer said they had satellite service in town. (One can only suppose they don’t like the phone or cable company).

The standard and technology used today for residential data delivery from satellites is DVB (Digital Video Broadcast). DVB was designed to deliver one-way downstream MPEG video signal and the application of this standard to data has been an afterthought. However, DVB is the standard of choice in the marketplace for data delivery since it is a simple standard that can be supported with low cost and easily available chip sets.

A new standard has also been developed for upstream satellite data – DVB-RCS (Return Channel via Satellite). This standard allows for two-way data services. Early satellite data products required a dial-up connection for outbound data, which basically defeated the whole purpose of having a high-speed connection.

Problems with Satellite Data

Satellite systems have some inherent issues that make it hard to design competitive data products. Some of these problems include:

- *Propagation delay*. Satellites have an inherent 280 msec propagation delay due to the location of geo stationary orbit of satellites.
- *Jitter*. Jitter quantifies the effect of network delay of packets arriving at the receiver in any Ethernet system. Jitter is calculated by measuring the inter-arrival time of successive packets. Advanced data services need low jitter.
- *Packet loss*. Packet loss causes degradation of any real time service. Packet loss is measured using BER (Bit Error Rate) – and advanced services needs a low BER.
- *QOS and traffic prioritization*. Packet switched networks are subject to congestion since data traffic is typically “bursty”. Congested networks wreak havoc for real-time services.
- *Compression techniques and standards*. The standard encoding scheme used with most satellite data uses very inefficient overheads and headers and wastes valuable data space.

However, the biggest issue with satellite data is always going to be cost. Today an Internet T1 over satellite costs at least $900 per month and that price is not likely to drop in the near future. Satellite is becoming a viable competitor in rural locations, but it is never likely to compete directly with any urban or suburban network. At this point there are no major companies out promoting satellite data and in addition, it is very hard for the average customer to implement a satellite solution.

B. Future Broadband Technologies

What is the likely migration for each of the existing technologies in the future? Also, are there any new technologies on the horizon that might bring broadband affordably to consumers?

Future of DSL

DSL speeds are expected to increase over time with new innovations. In the labs there have been DSL technologies tested with speeds up to 50 Mbps. However, the high bandwidth DSL variants tend to have characteristics that drastically shorten the bandwidth with distance. Distances for very-high-speed DSL is 1,000 feet or less and is expected to be useful in conjunction with Fiber-To-The-Curb (FTTC) deployments. A FTTC system would still require fiber traversing every street, but use copper drops and DSL instead of fiber drops. FTTH costs more than a FTTC system today, but can deliver tremendously more bandwidth.

Today, AT&T in the old BellSouth area is testing a DSL product that can deliver as much as 24 Mbps for up to 6,000 feet. This product consists of paired ADSL2+, meaning that the DSL is delivered over two lines. The biggest problem with this technology is that most neighborhoods were not designed with many spare copper lines. Traditional copper engineering has only provided 10% to 15% spare lines for a neighborhood, so there are not many households that can get this service. Also, 6,000 is a very short distance when looking at real streets. This is not distance as the crow flies, but distance as the cable runs.

Development labs are working toward DSL that might be able to generate as much as 100 Mbps. However, in real life all of the problems with copper would greatly diminish such speeds in the real world. However, one would think that in looking out over a 30-year window that DSL with speeds of 50 Mbps might be possible. Thus, 25 years from now DSL might grow to deliver 1/50 as much bandwidth as FTTH can deliver today.

Future of Cable Modems

Cable operators always have to balance the need for TV channels with the demand for data speeds. Today most cable providers are much more concerned about how to fit HDTV (High Definition TV) onto their system than they are about increasing cable modem speeds. The industry expectation is that cable providers will use any future increases in overall system bandwidth, or from increased CATV compression improvements to offer more channels rather than drastically increase data speeds.

As an industry we expect cable providers to deliver just enough data to stay ahead of the telephone companies and DSL, their predominant competitor. This is the expected nature of duopoly competition where competition is more based upon rhetoric than upon any real product differentiation. Cable executives are often cited as saying that they already deliver all of the speed that consumers need.

There are already cable modems tested in the lab that can deliver as much as 100 Mbps. However, cable providers are going to stick to products that can be mass-produced and sold in the mass market. Today cable modems are inexpensive since so many are produced. Cable providers are always going to be leery about increasing speeds since this will require all new hardware and massive rearrangements of their systems. Cable providers also will want to support only a few different modems in a given system, and the reluctance to swap modems will hold down innovation. Cable providers will upgrade modems only when competition forces them to do so. This is evidenced by Mediacom in New York City. They have introduced 15 Mbps cable modems to compete against Verizon's FTTH. However, they are the only cable company to do this and no other cable companies have announced any plans to even think about testing 15 Mbps modems.

Thus, the long term expectations for cable systems is that they will always offer products that are a little better than DSL, but not drastically better. The merger mania in both the telecom field and the cable TV field means that future competition is going to be mostly between a few big cable providers and a few big telephone companies. Cable companies have an inherent advantage in the battle since they already have full deployment of CATV programming and an advantage with cable modems compared to DSL. Since cable modems are inherently a little faster than DSL, cable companies have no incentive to be innovators.

<u>WiMax Wireless</u>.

The next generation of unlicensed spectrum technology is referred to as WiMax. Originally promised for 2005, it now looks like true first generation units just started hitting the streets in 2007. One would not expect a mature product until 2009, at the earliest.

The first generation of WiMax is being touted as having as much as 70 Mbps of shared bandwidth available to users. However, realistically we don't expect to see systems delivering that much bandwidth to customers for quite some time. WiMax has some of the same limitations as a cable modem system. The users on any WiMax antenna are sharing the bandwidth. The biggest challenge that a WiMax provider will have is getting the bandwidth to the transmitter. A fiber network is needed behind a WiMax system to feed the needed bandwidth to each antenna. A WiMax antenna needs as much as two DS3s of underlying broadband in order to serve customers. In most markets, getting that much bandwidth delivered to multiple antennas is going to be very challenging, and costly. In most markets the only vendor with this much bandwidth is the telephone company, and telephone company bandwidth is still very expensive. Additionally, the telephone companies are generally not equipped to deliver native Ethernet.

Our expectation is that WiMax is going to be used for wireless backhaul, meaning the delivery of data between two locations. We expect that Wi-Fi will continue to be the delivery mechanism to customers.

Gigabit Wireless

There are wireless technologies on the drawing board that may be able to deliver as much as one Gigabit of data (1,000 Mbps) over very short distances. For example, this spectrum could deliver bandwidth from a pole in front of a house to the computer and TV.

This type of bandwidth will only make sense when coupled with a fiber system. If the transmitters and receivers of this technology were made at a low enough cost, such a wireless technology could replace the drop to the house and act just like having a fiber to the house. Such a system would enable a customer to serve multiple TVs and computers and move them around at will without reliance on wires. However, only a fiber system can deliver enough bandwidth to make such a system work, so only FTTH or FTTC systems could support this breakthrough. This technology will depend on the availability of poles near houses, which will be a problem in the new neighborhoods with underground utilities.

Comparing Future Technologies

The following table shows our best estimate at the commercially available bandwidth that is available today and in the future with the primary commercial technologies. It is clear that fiber is today, and will remain for the foreseeable future as the most robust technology.

Data Download Delivery Speeds

	Today	**10-years**	**25-years**
FTTH	2,400 Mbps	10,000 Mbps	25,000 Mbps
DSL	Up to 12 Mbps	Up to 50 Mbps	Up to 100 Mbps
Cable modem	Up to 15 Mbps	Up to 50 mbps	Up to 200 mbps
WiMax	N/A	70 Mbps	200 Mbps
BPL	3 Mbps	50 Mbps	100 Mbps

C. The Right Technology for Prince George

The broadband surveys and interviews demonstrate a significant broadband gap in the County. The CCG research uncovered the following issues that were considered in determining a solution to solve the broadband gap:

Currently, Prince George County has

- Significant numbers of residents and businesses with no broadband access.

- No major telecommunication company point of presence (PoP) or SONET Ring;
- No major private sector telecommunication network that can insure uninterrupted service;
- A non-competitive environment in which telecommunications customers are forced to pay higher rates for service than their counterparts in the metropolitan areas.

The broadband gap has two aspects. First, there is a broadband gap for businesses. In order to keep and attract businesses today the County needs some way to deliver significant bandwidth to businesses. For example, data-centric business will want 10 mbps or 100 mbps connections to the Internet which is far faster than the products available from Verizon.

Second, there is a residential broadband gap whereby a large number of households can only get access to the Internet through dial-up. Households with children today need broadband if they are to keep up with modern education. Citizens who want to work at home require broadband. It is critical for the County to find a way to get citizens and businesses connected for economic and educational advancement.

CCG is proposing a two-part technological approach to solving the broadband gap. First is a recommendation to build fiber between the County Complex and the business park. Such a fiber could then be connected to any existing or future businesses that wanted to get real broadband. For the residential broadband gap the biggest challenge faced is the low population density and uneven distribution of populated areas. CCG is recommending a wireless network to bring broadband to the underserved residences and scattered small business in the County. This paper discusses the business models for supplying broadband in later sections.

Choosing the Right Technology

CCG looked separately at a solution for the business park and a solution for the residential broadband gap. We hoped we could find one solution that would have worked for both locations, but ended up with two different solutions.

<u>The Large Business Broadband Gap</u>

CCG considered two technologies for bringing large broadband to the Business Park – fiber and licensed microwave.

Traditional microwave equipment can deliver sufficient bandwidth to the business park. However, the use of microwave relies on the existence of towers located at the places the bandwidth is needed.

CCG is recommending that any broadband solution use the existing County Complex as the hub for any networks built. The County Complex is centrally located and has access to an existing County-owned tower.

In the case of the Business Park there is no existing tower in place. In order to use microwave to serve the Business Park a tower would need to be constructed. Further, using microwave would deliver bandwidth at the new tower, but would not deliver the large bandwidth to each business. In order to do that, fiber would have to be constructed from the new tower to each business. This network design would result in a network with fiber electronics operating out of a hut near the tower instead of at the central hub - not ideal from a network maintenance perspective.

In the end, when considering cost and network operation issues, the best solution for serving the Business Park is to build a fiber optics route from the County Complex to the business Park.

In examining the route between the County Complex and the Business Park it appears that most of the existing utilities are on poles. Thus, the fiber could be placed upon existing poles. The FCC has a requirement that existing poles owned by the telephone or electric companies must be made available to municipalities and other telecom providers as needed. Thus, these poles would be available to the County for hanging fiber.

There are two issues with using existing utility poles. First, working with the incumbent pole owners can be time consuming. Second, the FCC rules allow the incumbent to charge the new pole attacher for any costs needed in order to get on the poles. For example, there may not be a lot of space available on a pole and the existing wires might need to be rearranged in order to make room for the County. These costs are referred to in the telecom industry as make-ready costs. It's not untypical for make-ready costs to add 20% to a fiber network on poles (although sometimes there is zero make-ready cost).

The total estimated cost for providing fiber service to the Business Park is as follows:

- Fiber $185,000
- Make-ready Costs $ 37,000
- Fiber Electronics $ 60,000
- Business hookup (per business) $ 5,000

This fiber network would be capable of delivering significant bandwidth to the business in the Business Park today or in the future. For the price quoted above the network could deliver 10 Mbps or 100 Mbps to businesses within the park. With an increase in electronics cost the network could deliver 1 Gbps to businesses.

The Residential Broadband Gap

CCG considered three current technologies as possible solutions to the broadband gap:

- Fiber optic cable technology
- Broadband over Powerline (BPL) technology
- Wireless technology (licensed and unlicensed)

Fiber Technology

The fiber technology that could bring bandwidth to small business and residents is referred to as FTTH (Fiber-to-the-Home). In urban deployments FTTH costs around $2,000 per customer. Because of the rural nature of Prince George County and the scattered pockets of homes, FTTH would cost at least twice that much if deployed to everybody in the County. It appears that fiber is too expensive and there appears to be no viable business plan to pay for the investment. For the roughly 3,500 homes that would need FTTH, the deployment cost of just the fiber and the electronics would be at least $14 M. It's possible that a business plan that would provide cable television and voice in addition to data might be able to pay for such a network, but studying the triple play is beyond the scope of the CCG scope of work for this project. Even so, it's CCG's opinion that the cost of the network would probably make it hard to justify a FTTH network.

Broadband over Powerline (BPL)

Broadband over Powerline is a technology used around the world to serve rural customers. BPL is an interesting technology in that it requires no new wires and broadband is brought into people's houses on the existing power lines. Every electric outlet can be a broadband output for a computer. However, there are several issues that make it an unlikely technology candidate for the County:

- BPL can only be deployed by the electric company, who owns all of the electric lines. Since Prince George is served by two different electric companies, both would have to agree to deploy BPL in order to solve the County's broadband gap.
- The first generation BPL equipment doesn't deliver very much bandwidth. The test deployments in the US are delivering less than 1 Mbps to customers. While much better than dial-up, this is not the broadband needed for the future.
- Lack of sales of BPL in the US has slowed the industry down to a crawl. There have been so few deployments of BPL in the US that the manufacturers are doing little product development or innovation. There is a robust BPL industry in Europe, but the European electric grid is different and their technology does not work here.

- Rural deployments can get expensive. A BPL network requires a device on a pole to bypass every electric transformer. In suburban areas where houses are close together a BPL network might cost $500 per home. In a rural setting like Prince George the BPL network would cost at least twice that much.

In the end, BPL doesn't look like a realistic alternative in Prince George. If the US BPL industry ever released a better technology, then it's possible that the electric companies in the County might consider deployment.

Wireless Technology

The final technology, wireless communications looks to be the best alternative for solving the residential broadband gap in Prince George. There are many different wireless technologies and the one being considered in this study for Prince George is the use of unlicensed spectrum using WiFi (IEEE Standard 802.11) and WiMax (IEEE Standard 802.16). The advantages and possibilities of wireless are quite compelling:

- Deployment Cost – Infrastructure deployment costs are far below those of fiber and probably less than BPL.
- Mobile Component – It is the only broadband technology with a mobile capability. Along with bringing broadband to homes and small businesses, the County could deploy hotspots in key locations to allow access to the network with laptops and handheld devices.
- Expanding Technology – Unlike BPL with few deployments, the wireless industry is exploding and equipment vendors are busy developing the next generation of equipment.
- Delivers Decent Bandwidth Today – The network contemplated in this study could deliver around 3 Mbps download speeds today and could be upgraded for faster speeds in the future.

The biggest drawback to most municipal wireless systems is that they have been designed with inadequate backhaul. That is, there is not enough bandwidth delivered between the network hub and each tower site. In poorly designed networks the bandwidth delivered to customers fluctuates and is generally in the range of 1 Mbps. CCG has proposed network that solves the backhaul problem.

Another issue to face for a new network is connecting the network to the Internet. Although the Prince George County region is traversed by a number of fiber optic backbone network lines connecting the Charlottesville, Richmond, Roanoke, Lynchburg, Danville corridor, very few of these fibers terminate in or bring any benefit to the County. Today, within the County, the only access point to the Internet would be through Verizon. Verizon would only sell bandwidth to the County at retail rates, making it too costly to afford to deliver bandwidth to customers. CCG recommends that if a broadband network is built that the network plans also consider building a fiber to reach a better Internet meet point.

CCG’s research considers two alternate points for cheaper Internet access. The first option is to build a fiber about five miles to Petersburg where there may be several options for Internet connection. A second and possibly better alternative would be to build fiber to meet the Mid-Atlantic Broadband Cooperative. While the Cooperative does not have fiber close to the County today, they have suggested several different routes that would come close to the southern border of the County. It would require between about five miles of fiber to connect to this potential meet point. Note that the Mid-Atlantic Broadband Cooperative is a group that serves many governments in Virginia and surrounding states. They have built a robust fiber network, much of it funded by tobacco funding, and bring very affordable broadband to local government networks. They just recently indicated interest in building to the County just after the Rolls Royce announcement. As an aside, the County should also take note of a paper that was written a few years ago by Jeff Crowder of Virginia Tech that looks in detail at the presence of fiber and Internet POPs in Virginia.[1] This paper shows the location of likely Internet POPs.

The wireless network recommended by CCG can deliver real broadband. As designed, this network could deliver 3 Mbps second to homes and small businesses. The technology can also deliver up to 17 mbps to a select number of larger businesses that are outside the Business Park. The technology can be upgraded and in the future could deliver even greater bandwidth.

Broadband Coverage of the County

The network designed by CCG could cover all or most of the homes and businesses in the County. Coverage of the proposed networks in shown with a series of maps located in Section II.J below.

The network also could be used to connect to schools, libraries, health care and other government facilities. Any location near to the proposed fiber routes could get very high bandwidth. Everywhere else in the County could get instant access to around 3 Mbps download speeds. If any government or health care locations needed greater bandwidth than 3 Mbps, then over time the County could expand the fiber network to get so such locations. Since most businesses and government facilities are located in the northern third of the County, adding additional fiber could be done affordably. Also, the routes being proposed by CCG could be modified and lengthened such that they pass more key locations.

[1] Access to Tier One Networks for Rural Virginia Counties, Jeff Crowder, April 2004.

II. Preliminary Engineering Design and Cost Estimates

This portion of the report will look at the specific design criteria and considerations for designing a wireless network in Prince George with sufficient capacity to solve the broadband gap.

A. Wireless Network Design Parameters

There are some key characteristics of wireless technology that must always be considered when designing a wireless network.

A wireless network configuration consists of one or more antennas placed upon towers. The transmitting equipment at the towers is referred to as a wireless base station. The antennae at the base station transmit data to nodal access points (nAP) located at or near to customer locations. There are several different network configurations possible for deploying access points, which will be discussed below. There are many different network configurations possible for the deployment of access points, which will be discussed below.

The number of needed access points in a given network depends upon:

- Line of Sight. Unlicensed networks require that the customer's receiver must have direct line of sight with the transmitting antenna. However, with mesh technology, the customer must only have line of sight with another customer.
- Height of the tower(s). Each frequency has an ideal tower height mounting location for maximum range and performance.
- Transmitter power – limited by FCC regulations
- Frequency band – The higher the frequency the shorter the distance the frequency is viable (and the smaller the coverage range).
- Bandwidth vs. range – There is also a trade-off between bandwidth and distance. The greater the amount of bandwidth being delivered, the closer the antenna must be to the customer.
- Receiver Sensitivity – Improved sensitivity of the access point, in terms of signal-to-noise ratio will extend the distance between the transmitter and the access point.

When designing a wireless network, CCG uses the following performance criteria in determining the best design:

- Must be modular, in that the same types of receivers ought to work anywhere in the County;
- Must be scalable in that the network can be expanded to cover a new housing development added after the initial design;
- Must have as much redundancy as possible;
- Must allow for upgrades to future technology such as WiMax;
- Must work today without fiber but be ready to interface with fiber in the future;
- Must have carrier class backhaul to allow for uninterrupted and steady delivery of bandwidth to customers.

Unlicensed spectrum implies the potential use of three different spectrums which have all been set aside by the FCC as 'unlicensed spectrum". This includes the WiFi/WiMax bands of 900 MHz, 2.4 GHz and 5.2/5.8 GHz). There are transmitters designed to use each of these frequencies. The good brands of access points are capable of receiving any of these frequencies.

The configuration of the network will determine how many access points are needed to get good customer coverage. In general, access point densities of 5 to 6 per square mile are typically required in a rural setting. Deployments in suburban areas might require between 16 and 25 access points per square mile. Urban areas might require as many as 60 access points per square mile. The number of access points also vary depending upon which of the three frequencies is being used. For example, using the 900 MHz band will require fewer access points than the 2.4 GHz band.

The access point density must be matched with population and housing densities. For example, the northern one-third of Prince George County has over 211 persons per square mile. The bottom two-thirds in the south and eastern corner of the county has less than 58 people per square mile[2]. The density of the top one-third part of Prince George would require more access points per square mile, but would still have the lowest deployment cost per customer due to customer density. The network in the bottom two-thirds of Prince George is costlier per customer.

<u>Wi-Fi versus WiMax</u>.

Anybody who follows the wireless industry has been inundated for years about the next generation of wireless equipment referred to as WiMax. Today, all of the deployed networks use WiFi technology. While WiMax technology has been heavily hyped there is no WiMax equipment yet on the market[3]. There is Wi-Fi equipment that deploys some of the proposed features of WiMax, which CCG refers to as pre-WiMax equipment. There are two proposed features of WiMax that offer improvements over WiFi. First, the FCC has opened up a new frequency for WiMax in the 3.65 GHz range. While this new frequency will be unlicensed, the first user of the frequency in a given area will enjoy some of the protections normally given to licensed spectrum holders. For example, future users of the frequency will be required to coordinate such as to not interfere with the first deployment. The second big advantage touted for WiMax is improved backhaul. The proposed CCG solution proposes a more robust and reliable backhaul than will be delivered by WiMax. Thus, CCG warns the County that if you deploy our solution that you should not be deceived by industry sales hype. While we think it would make sense to consider and even test deployment of the new unlicensed frequency, we would sternly warn that it is a very bad idea to deploy a full network using first generation equipment. The first people testing WiMax will be guinea pigs as the vendors work out all of the kinks and bugs. CCG always cautions clients to wait until a technology is proven before

[2] US Census 2000.

[3] FCC ruling establishing new frequency and setting WiMax standards was recently released in June 2007.

relying on it for commercial purposes. Second, CCG is already proposing a network with carrier class backhaul, far better than will be delivered using WiMax.

What is important is that if WiFi is deployed today, equipment chosen must have the ability to be upgraded to WiMax without a forklift upgrade. With upgradable equipment the County would eventually be able to take advantage of the new WiMax frequency. Not all WiFi manufacturers will have a clear migration path between WiFi and WiMax.

B. Network Architecture

There are four possible major network architectures that can be used for the deployment of a wireless networks, as follows.

Point-to-Point. The point-to-point (PTP) wireless network is the simplest of all four network architectures; it connects one single point to another single point. The biggest advantage of the PTP architecture is that a very large amount of bandwidth can be delivered between the two points. There are several disadvantages to a PTP network. First, this is quite costly since there must be a 2-way radio at both locations. Next, this kind of network is difficult to migrate to other types of architecture. Requirements such as antenna selection, line-of-sight determination, site surveys, hardware costs, facility costs, installation, testing and support all play important roles in the PTP network architecture. The point-to-point network architecture is most appropriate choice when trying to bring a large amount of bandwidth to a very small number of locations. A pint-to-point network will not bring a broadband solution to the underserved homes and businesses in Prince George County.

Point-to-Multipoint. The Point-to-Multipoint (PMP) wireless network can be the most economical way to provide connectivity from a single hub site to multiple end user locations. The advantages of the PMP network architecture are that such a network is affordable, scalable and open for upgrades to new technology. There are also some disadvantages. The primary disadvantage is that a PMP network requires line-of-sight between the transmitter and the customer. This means that trees, buildings and hills can block coverage. A second disadvantage (and maybe also an advantage) is the shared nature of the bandwidth. The bandwidth is shared between all customers from a given transmitter. This means that if a PMP network tries to serve too many customers, the bandwidth will suffer. A key assumption with a PMP network is that affordable bandwidth can be brought to the base stations. This is referred to as the backhaul issue and is discussed in more detail below. A third problem with a PMP network is the availability of antennas. Most antennas today are built for cellular traffic, meaning that the towers sites are not chosen with line-of-sight considerations (cellular spectrum can pass easily through trees and bounce over hills somewhat). The Point-to-Multipoint network architecture is most appropriate when many users are located in the same general area and when there is clear and open terrain.

Cellular Architecture. When several point-to-multipoint networks are networked into the same backbone network, the result is a cellular network. The advantages of the cellular architecture include the expansion in coverage area, an increase in network capacity, and redundant end user coverage. The single biggest disadvantage of the cellular network is interference. The signals from the multiple PMP networks interfere with each other where they overlap in coverage. Cellular network architecture is the most appropriate when there are more end users in a given area than can be served using only a single point-to-multipoint network. The overlapping of multiple PMP networks can bring expanded coverage at peak hours.

Mesh Architecture. The Mesh architecture is a multipoint-to-multipoint (MMP) architecture with at least one Internet connectivity point. In a mesh network each network node can connect to any other network element that is within range. The biggest advantage of a mesh network is that it largely solves the line-of-sight issue since customers most likely will be able to see at least one other customer. Another advantage is that the equipment is extremely flexible - each node performs two key functions: routing/repeating and termination[4]. One disadvantage of the mesh architecture is that the nodes must be within close proximity in order to be meshed. Another disadvantage is that putting nodes close together creates additional noise and interference. A final disadvantage is that the amount of bandwidth that can be delivered to a customer drops roughly in half every time the bandwidth is bounced through an additional node. Thus the challenge of designing a mesh network is to have enough nodes so that every customer can see a node, but not to have so many nodes that the interference overwhelms bandwidth delivery. Most urban municipal networks today deliver poor bandwidth because they have crammed too many nodes into a small space. The best use of a mesh network is when there are scattered pockets of customers. The network design must also be very careful to not allow very many bandwidth hops between nodes.

C. **The "Middle Mile" Issue**

Internet users connect to the global network through an Internet service provider, or ISP. The ISP connects to the Internet through an IBP (Internet Backbone Provider). An IBP business that sells high-speed access to the main Internet "pipes" that crisscross the United States, Southern Virginia and Prince George County. The location of these “pipes” is abundant but secretive. The connection between an ISP and the Internet Backbone is often called the "middle mile."

In rural areas, this connection can be very expensive. A recent study by NECA, an organization that works with rural telephony and broadband, shows that the middle mile may be the driving factor in pricing rural Internet services[5]. One of the key factors to the success of the proposed

[4] Data packets can travel through several intermediate wireless nodes to reach the desired end user node. If one or more nodes are down, the data packet is rerouted through other intermediate nodes.

[5] “Middle Mile Broadband Cost Study”, 2001. National Exchange Carriers Association (NECA). ***The results of the study show that 55% of rural telephone company switches are more than 70 miles away from an IBP node, 10% are more than 200 miles away.*** Using very conservative pricing and network design assumptions, the cost per line for transporting high-speed traffic to these nodes ranges from $17 per line to $8,754 per line at a 0.5% level of market penetration. The average cost per line drops as market penetration increases because of economies of scale in transporting traffic. At a 0.5% penetration rate the average transport cost per line is $251 per month, at 5% penetration it is $53 per month, at 10% penetration it is $41, and at 15% penetration it is $36 per month. Penetration rates chosen cover a range of likely market penetration levels over the next three years.

network is the ability for Prince George to find affordable access to the Internet Backbone. There appears to be no such connections inside the County, so the network design is going to need to look outside the County for cheaper bandwidth. There are multiple potential sources of lower cost bandwidth that include: 1) building to a connection point in Petersburg or elsewhere, 2) building to meet the Mid-Atlantic Broadband Cooperative, or 3) possibly sharing backbone bandwidth with Fort Lee.

D. Final Network Design

After considering all of the issues discussed above, CCG undertook a design of the network using the following steps:

1. Looked at maps and drove around the County to understand the underserved areas;
2. Looked at available towers owned and available in the County;
3. Looked at customer density and proximity to transmitter sites;
4. Evaluated the point-to-point architecture;
5. Evaluated point-to-multipoint architecture;
6. Evaluated cellular architecture;
7. Evaluated mesh architecture;
8. Found a solution for the backhaul issue;
9. Found a solution for the Last Mile issue;
10. Chose the best solution for delivering bandwidth to customers;
11. Equipment selection process.

Backhaul

As discussed earlier, one of the biggest drawbacks in most wireless networks that they don't deliver enough bandwidth to each of the transmitters. For example, most municipal wireless networks today use the same radios to connect between towers that are used to deliver bandwidth to customers. With such a design the amount of bandwidth available to customers is greatly reduced and compromised. The busier the network becomes, the lower the amount of bandwidth that can get through. Such a network will develop 'choke points' where there is a trade-off between bandwidth available to deliver to customers versus bandwidth used to get to the Internet.

CCG is recommending that the Prince George wireless network avoid the traditional backhaul problem by creating a backhaul that uses separate technology than the wireless network used for customers. The two possible backhaul solutions are to use fiber or licensed microwave, and CCG determined that the lowest cost initial solution is to use licensed microwave to deliver bandwidth to various parts of the network. This would then allow the full amount of WiFi bandwidth to be used for customers.

Basic Network Configuration

CCG determined that the best network to serve customers uses a combination of two network configurations:

- Cellular configuration using omnidirectional or sectoral access points as used in cellular/PCS mobile networks;
- A mesh configuration such as is used in many municipal WiFi networks.

As will be seen in the detail below, the cellular configuration means that the network will deploy new transmitters in three locations rather than from just one central spot in the County. Such a deployment will insure adequate coverage for all parts of the County.

Use of the mesh configuration means that CCG is recommending the use of customer receivers that will allow customers to get a signal from their neighbor rather than directly from one of the three transmitters. Because the County is relatively flat, and since the available towers are tall, it appears that a large percentage of customers ought to be able to get signal directly from one of the three proposed towers. However, customers who are obstructed due to trees, another building or a hill will be able to get signal by bouncing the signal from one of their neighbors. CCG expects that almost every home and business in the County ought to be able to get a signal.[6] There may be isolated customers, such as one surrounded by a dense pine forest, that might have trouble getting signal.

E. Phased and Modular Architecture

CCG is also recommending a network that includes a 'modular' deployment strategy to minimize the capital expenditure and maximize the return on investment. CCG is recommending an initial network that consists of three transmitters at existing towers. These towers (Headquarters, Middle Road and Burrowsville) would be connected using dual point-to-point licensed wireless microwave links to maximize the delivery of bandwidth and to provide redundancy.

The modular nature of the design means that this network could be expanded to use all of the seven existing towers in the County. Such growth of the network might be needed if the network gets more customers than predicted by this study or if significantly more homes are built in the County. Any new nodes could be incorporated into the ring architecture for redundancy or to expand the network to incorporate public safety and other systems into the network. CCG believes that in the long run the County would best be served by one network that carries all of the County's wireless traffic.

Below in Figure 1 is a map of the exiting towers located in the County as well as the existing public safety network. This diagram shows that the public safety network could eventually be incorporated into the proposed WiFi network and that the entire network could be expanded to have more redundancy.

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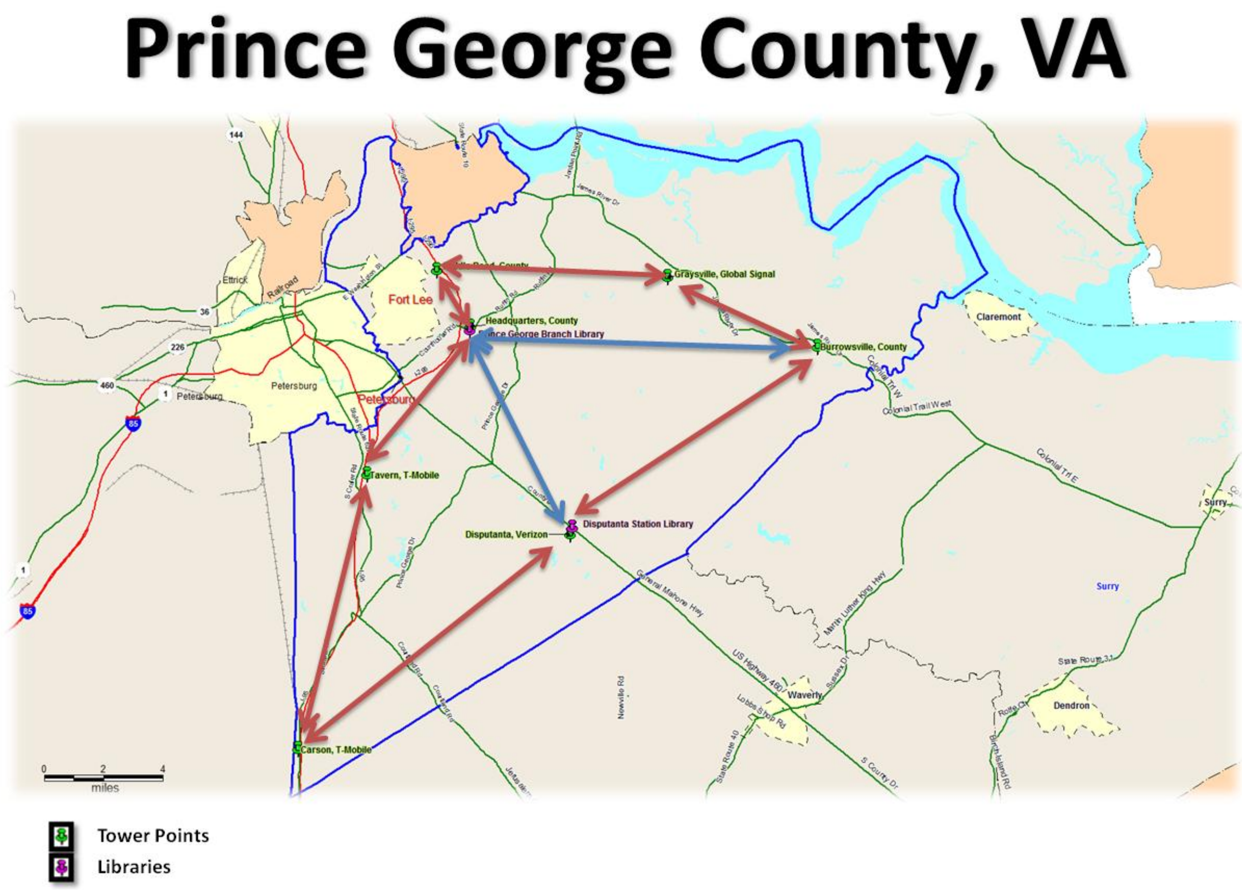
[6] CCG notes that the coverage maps below indicate a few hundred homes in the southwest portion of the County that won't have direct coverage from the proposed towers. However, there are technologies available to extend the signal from the other towers, i.e. signal boosters and repeaters that should be able to get bandwidth to these customers.

The red routes on Figure 1 indicate the routes currently used for the UHF public safety network in the County. The blue routes show smaller rings that can be added for future expansion that would allow for more capacity and that would add redundancy.



F. The Three Base Stations

As discussed earlier, CCG is recommending the creation of a backbone using licensed microwave frequency. CCG determined that microwave can deliver enough bandwidth and still cost less than fiber. The initial microwave ring will consist of three tower sites and roughly 27 miles of transport. Further, CCG is recommending a dual microwave link using two bandwidths so that the network is completely redundant. The backbone network would consist of two separate rings, one at 6 GHz going clockwise that could deliver 155 Mbps of bandwidth and a second ring going counterclockwise using either 6 MHz or 11 MHz that would deliver 2 OC3's, or 311 Mbps.

Traditional microwave technology has been in place since the 1970s. The equipment is affordable and incredibly reliable. Fixed microwave wireless was at the heart of MCI's original network and is still used all over the world to deliver significant bandwidth.

Based upon potential points for Internet connectivity, and based upon getting the best coverage for customers, CCG chose three existing towers in the County as the initial deployment spots for the backhaul network. The three towers are at the County Government Center (HQ), at Burrowsville and at Middle Road. CCG looked at household density when choosing these three towers, but we recommend a more detailed wireless coverage study before finalizing the specific antennae locations.

CCG is also recommending that the hub of the network be located at the County Government Center. There appears to be space for equipment there and the location is a natural spot for monitoring the network (since it's already the location used to monitor other existing network connections). The backbone network would look as follows in Figure 2:

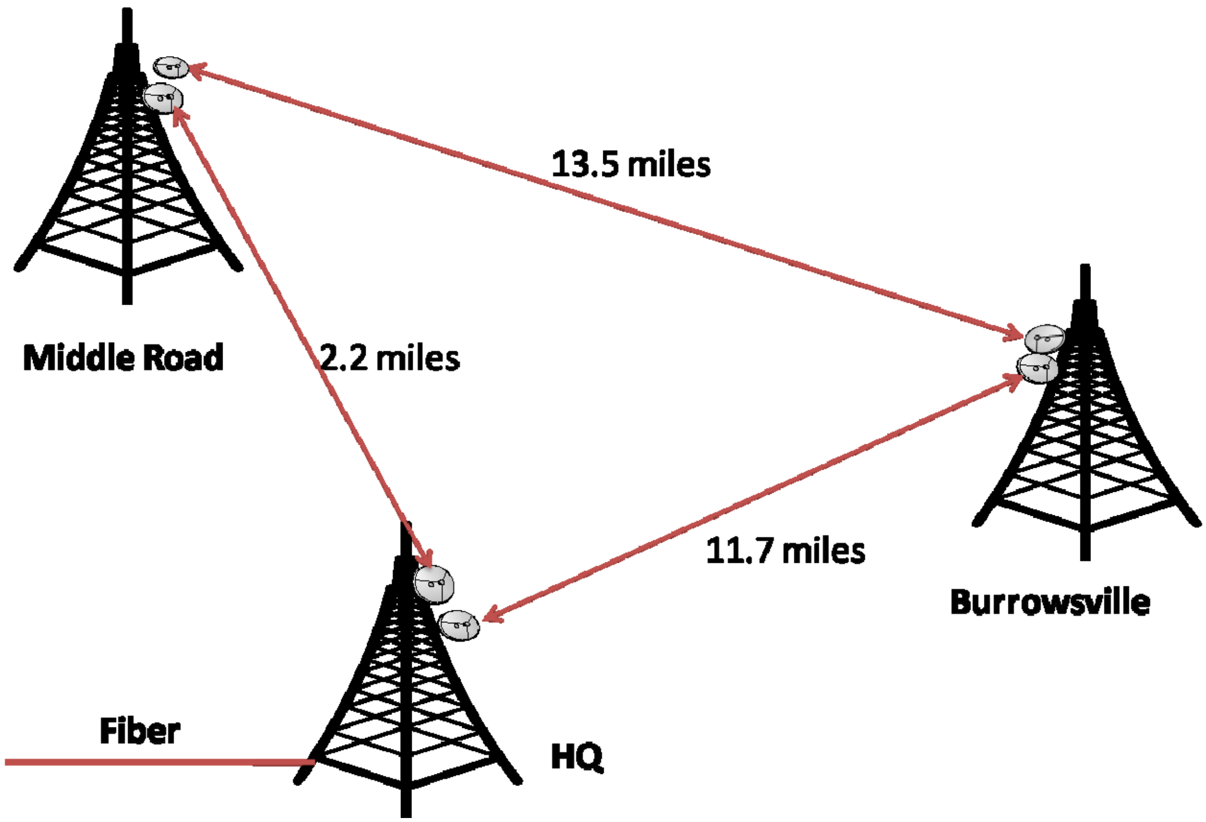


Figure 2 illustrates a wireless ring consisting of a single gateway (HQ) site and 2 access sites.

Key challenges for wireless network providers, particularly in rural areas, are obtaining the high speed connection needed to link the wireless system to the Internet, quality of service and supporting legacy systems. All three issues can be addressed through the phased construction of a wireless SONET system and radiating 'mini cells' to the desired service areas (Figure 3).

G. The Concept of Mini-Cells

The network, using three towers, will be able to see many customers directly. It's likely that more than half of the potential customers in the County would be able to see one of the three towers and get service with a direct shot. A customer might get signal from a different tower than his neighbor, depending on which tower each could see. All other customers would require a signal hop from a customer who can see a tower directly. This is a function performed by the mesh network capability of the customer receivers. Each customer unit can serve two functions – to receive a signal for the customer at that location, and to bounce a signal to a nearby customer.

As discussed earlier, it's very important to minimize the number of hops needed to get to customers. The amount of bandwidth delivered to a customer drops roughly in half with each frequency hop on a mesh network. Thus, in order to deliver 3 Mbps guaranteed download speeds it is vital to never make more than three hops, and preferably not more than two hops.

The mesh feature of Wi-Fi networks was developed as an urban and suburban solution. Access points are designed to constantly search among neighboring access points for the strongest signal, particularly in an environment where many access points are close together. Thus, an access point in a congested area can pick out one of many possible paths in order to create a frequency hop. This process is dynamic and each customer access point is constantly seeking the strongest connection.

While this feature makes it easy for a customer in an urban environment to make a connection, this feature of a mesh network actually degrades service in a rural environment where customers are further apart. Every time that a customer access point looks for its neighbors (referred to as pinging), it is wasting bandwidth that cannot be used for customer throughput.

In a rural environment CCG believes that the best solution is the creation of mini-cells. This involves programming customer access points so they can only see close neighboring access points. In creating a mini-cell a technician is pre-configuring the access points in a neighborhood to get access to customers without a direct line of sight to one of the three towers. By pre-configuring the local mini-cell connections, the pinging feature of the access points is disabled to save bandwidth and reduce interference. The final network would consist of a number of these mini-cells in various neighborhoods, where neighboring mini-cells do not interfere with each other.

H. Specific Design Features of the Wireless Backbone Network

This study considered licensed microwave because of recent drastic cost reductions in licensed microwave equipment. Single radio units, which can cover distances of over 15 miles and speeds of 155 Mbps cost as little as $32,000 per end point.

These units are easily managed through a Web management platform, and provide five nines reliability (referred to in the industry as carrier class). From a technical perspective, the bandwidth delivered over microwave is indistinguishable from bandwidth delivered over fiber. External connection to the Internet or to other existing legacy systems can be handled using Add

Drop Multiplexers (ADM) equipment which cost about $64,000 per link. These ADMs are the same equipment used in traditional fiber SONET networks that are used by Verizon. CCG is recommending SONET technology on the wireless ring to take advantage of the ability of the microwave rings to quickly reverse directions in case of equipment failure at one link. This ability means that the network will not fail due to the failure of a radio at a single site.

The implementation of ADMs at the ring layer has the added advantage of allowing the deployment of traditional point-to-point TDM services (i.e., voice, T1s and DS3s). One of the biggest advantages of this architecture is that this system could eventually be used to tie-in to all other County telecommunications systems and services. The proposed network is carrier class, and by the use of ADMs this system could integrate into any other architecture from public safety, libraries, Ethernet, and voice. With proper planning, the proposed system could eventually be the backbone for all County communications and data.

This network is designed as a ring for redundancy purposes. The traffic to the Internet is sent in both directions around the ring. Thus, if one tower goes down, the others towers would keep functioning. If one of the wireless links fails, the remaining links would still function, at a slightly reduced capacity.

One of the most important aspects of the proposed network is that maximum bandwidth is made available at each radio transmitter. This network avoids the biggest choke point of most municipal wireless networks – most networks use inadequate backhaul and such systems have diminished capabilities before the signal reaches all of the towers. The more bandwidth that is available at each tower site, the more output can be achieved by customers.

The CCG design is a "minimum" scenario for the network. If over time the network added more customers or adder more bandwidth to each customer, the network has been designed to grow as needed. If the network grew significantly, at some point the three microwave links could be replaced by fiber links.

While CCG recommended a specific network solution, CCG cautions that the County will need to do due diligence rather than directly implement the recommended solution. The County should first talk to others who operate similar networks to learn about the problems and successes they have had. It is also important to get referrals from the equipment vendors. A good vendor will let you talk his other customers, and one that won't give referrals should be avoided.

I. Key Features of Wireless Ring Architecture

CCG is proposing the deployment of a wireless ring network and further proposes the use of narrow beam, point-to-point radios such as those available from Harris, Alcatel or Proxim.

This wireless point-to-point network architecture is inspired by ring-oriented designs used in many fiber optics SONET networks. SONET ring designs, such as the Unidirectional Path Switched Ring (UPSR) or the Bidirectional Line Switched Ring (BLSR), automatically switch to protection channels in the event of an isolated network failure. The point-to-point architecture is also a ring-like network design in which traffic is automatically redirected to an alternate route in the event of a single radio or a radio link failure.

The recommended wireless point-to-point networks has the following advantages:

- ✓ self-healing
- ✓ dense deployment
- ✓ incremental deployment
- ✓ cost effectiveness
- ✓ scalability
- ✓ spectral efficiency
- ✓ high subscriber capacity
- ✓ manageability
- ✓ in-service upgradability
- ✓ ability to overcome line-of-sight obstructions

A wireless ring network consists of a series of access sites interconnected in a ring-like network by a series of broadband radio links. At least one of the access sites, designated as the gateway, serves as a link to a wide area network (e.g. the Internet) or a higher level backbone network. All non-local traffic passes through the gateway site(s).

A wireless ring network differs from other common radio network designs, such as point-to-point, point-to-multipoint. It is unlike a point-to-point network in that it consists of a whole series of sites interconnected by radio links, rather than a single radio link interconnecting two sites. The interconnected radios act in concert to achieve high reliability. It is unlike a point-to-multipoint network in that all sites are served by the full available bandwidth, rather than some fraction of the bandwidth. The wireless ring architecture is very similar to a cellular architecture consisting of a backbone.

All of the wireless ring radios consist of two basic types. These are the Ethernet (100 Mbps) wireless ring radios and the SONET OC-3 (155 Mbps) wireless ring radios[7]. The wireless ring radios from either type can be integrated into the proposed design.

<u>Self-Healing</u>

A major feature of the wireless ring network design is its ability to reroute customer traffic around a single failed radio or radio link. In the example of Figure 3, if the radio link between tower #1 and the HQ tower were to fail, all traffic that would normally flow between those towers is redirected in the other direction around the ring. In a network consisting of SONET radios, the SONET Add/Drop Multiplexers can be added at each

[7] For a SONET OC-3 wireless ring network, each radio link acts as an “invisible fiber” to carry the 155 Mbps OC-3 signal in both directions between the add/drop multiplexers located in each tower. A wireless radio-based OC-3 network design is exactly analogous to a typical fiber-optic deployment. The only difference is that the bidirectional OC-3 signal is carried through the air.

site to perform the rerouting. When failures are artificially created in lab, the rerouting consistently occurs in less than 15 seconds.

Dense Deployment

Unlike some point-to-multipoint network designs where subscriber radios must be placed within narrow angular sections, the wireless ring architecture allows for very flexible and potentially dense deployment of wireless ring radios at customer sites. There is no geographical limit on exactly where radios can be placed as long as the hop distances are kept within the allowed limits and the radios do not interfere with each other. The potential for interference is minimized by the use of a high-gain antenna with a narrow beam width of 10 degrees. A narrow beam width allows all radio links to be placed within close proximity to each other. Another feature of modern microwave radios on the market today that limits interference is the use of Adaptive Power Control. Adaptive power control automatically adjusts the transmit power of each radio to keep it at the minimum output level needed to maintain a 99.999 percent link availability during rain events.

Rapid Deployment

A wireless ring wireless network is relatively quick to deploy, especially compared to cable-based networks, which require digging permits to be obtained and cable to be buried in the ground. To deploy a wireless ring network, tower access rights and access to the telecom room must be obtained for each site.

Incremental Deployment

A wireless ring network can be built out incrementally such that service to existing customers is not interrupted, even as new towers and customers are added to the network. Adding a new tower to an existing ring requires a new radio link to be spliced in. The primary service path must be temporarily broken and traffic rerouted to alternate paths for a short period while the new link is spliced in. If needed, a new ring can be created at any time to add a new set of buildings to a service area.

Cost Effective

In addition to allowing for rapid deployment, the advantage of not having to lay cable also contributes to the cost effectiveness of a wireless ring wireless network. Obviously, installing cable in the ground is expensive. The cost savings of a wireless network are somewhat offset by the expense of spectrum ownership, but ultimately installing a wireless network is less expensive than installing a cable network.

Scalable

Wireless ring networks are scalable to whatever size is needed. If an existing ring is not yet fully saturated, a new customer or service can be spliced into it by the addition of a new point-to-point link. If an existing ring becomes too large, a new ring can be created (Figure 2 – blue routes).

Spectral Efficiency

This design enables an efficient use of the available RF spectrum. Because of the wireless radio's narrow beam width a single transmit and receive channel pair can be reused by every radio link in a network.

High Subscriber Capacity

A wireless ring network can deliver the full network capacity to every customer on the network.

Manageable

A wireless ring network is managed through a separate channel of RF bandwidth reserved for that purpose. This network management channel is called the "radio overhead" channel. It does not steal any capacity from the either the 100 Mbps Fast Ethernet channel or the 155 Mbps SONET OC-3 channel. Any wireless radio in a network can be reached through the radio overhead channel using Ethernet and TCP/IP protocols.

Ability to Upgrade in Service

Once a wireless ring network is installed and commissioned, the need occasionally arises to upgrade. Fortunately, it is possible to do this without interrupting service to customers for more than a few seconds. The software update process for a single wireless ring radio involves first downloading new software to the radio's nonvolatile memory channel. The next step is to reboot the wireless ring radio. While the radio is rebooting and the radio link is down, affected customer traffic is re-routed along alternate paths as previously described. Customers see only a brief service interruption lasting no more than 15 seconds or less for SONET OC-3. To limit the effect on customers, software upgrades can be done during off peak hours.

Can Overcome Line-of-Sight Obstructions

A wireless ring network lends itself well to situations where there are obstructions to the line-of-sight between the gateway tower and the outlying customer service areas. The network can be geographically arranged so that the radio links angle around line-of-sight obstructions. Linking the radios from tower to tower also makes it possible to reach customers that are much further away from the gateway than the maximum single hop distance.

Summary

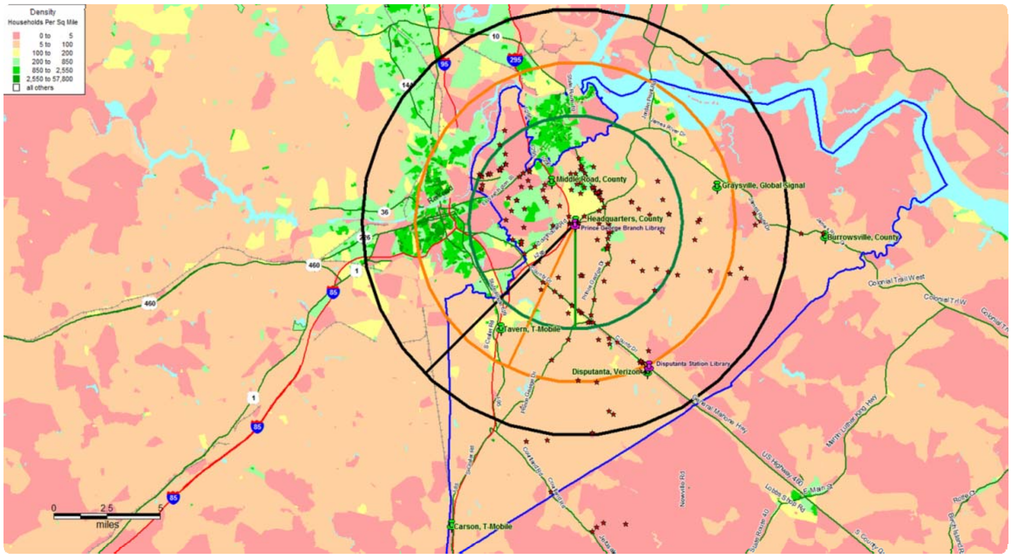
Wireless ring networks have several advantages over other common network designs. When radios are deployed in a ring configuration, alternate routing paths protect customer traffic from radio failures or radio link failures. Alternate routing paths also make it possible to replace or upgrade radios without shutting down the entire network. In combination with narrow beam width and adaptive power technologies, wireless ring technology allows denser networks to be deployed. The same technologies also enable radio frequencies to be reused in close proximity without interference. Wireless ring networks are flexible with regard to radio placement, such that obstructions can be avoided and large areas covered.

J. Connecting to Customers

From the three towers, connections can be made to customers by using unlicensed frequency transmitters to connect to a receiver at each customer. CCG is recommending that the County network deploy three transmitters at the County Complex and at the Middle road tower site using the three different unlicensed frequencies - 900 MHz, 2.4 GHz and 5.2/5.8 GHz). The use of multiple frequencies increases the number of end-users that can be reached from each tower and also decreases radio interference by having customers on different frequencies. At Burrowsville it's only necessary to use 900 MHz initially, although more transmitters could be added there if there is more demand.

Each of the three frequencies also has a different coverage pattern with 5.2/5.7 GHz coverage represented by the smallest circle, 2.4 GHz coverage represented by the middle circle and 900 MHz coverage represented by the largest circle. The following three maps show the coverage that can be obtained from each of the three base stations using the three frequencies. Following this is a summary map showing the coverage obtained with all three base stations. Note that in this depiction that only two sectors of the Burrowsville footprint are shown, since there would be no need to send the signal to surrounding counties.

Prince George County, VA

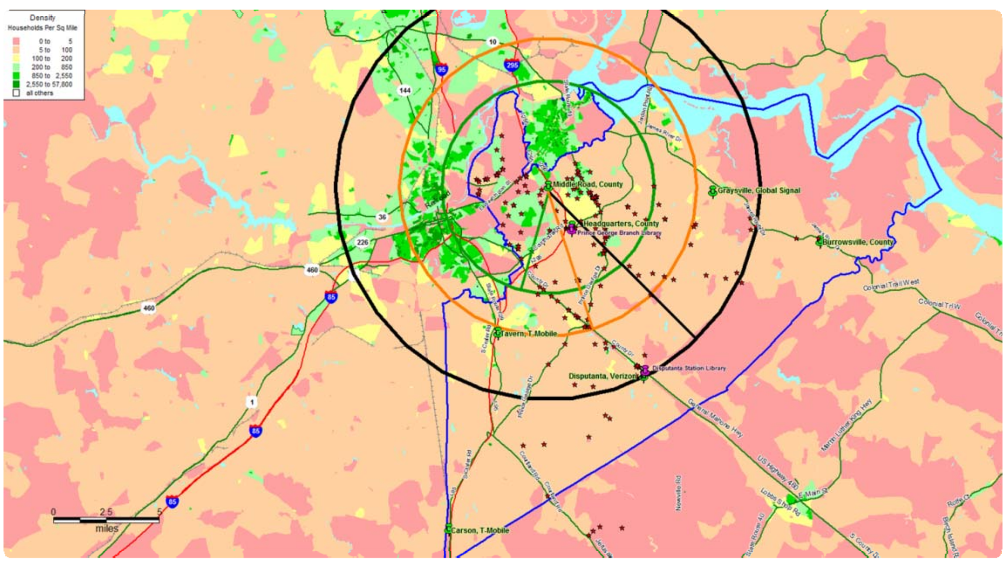


Tower Points
Libraries
Businesses

5.7GHz Motorola Canopy (5 mile radius)
2.4GHz Motorola Canopy (7.5 mile radius)
900MHz Motorola Canopy (10 mile radius)

Headquarters

Prince George County, VA

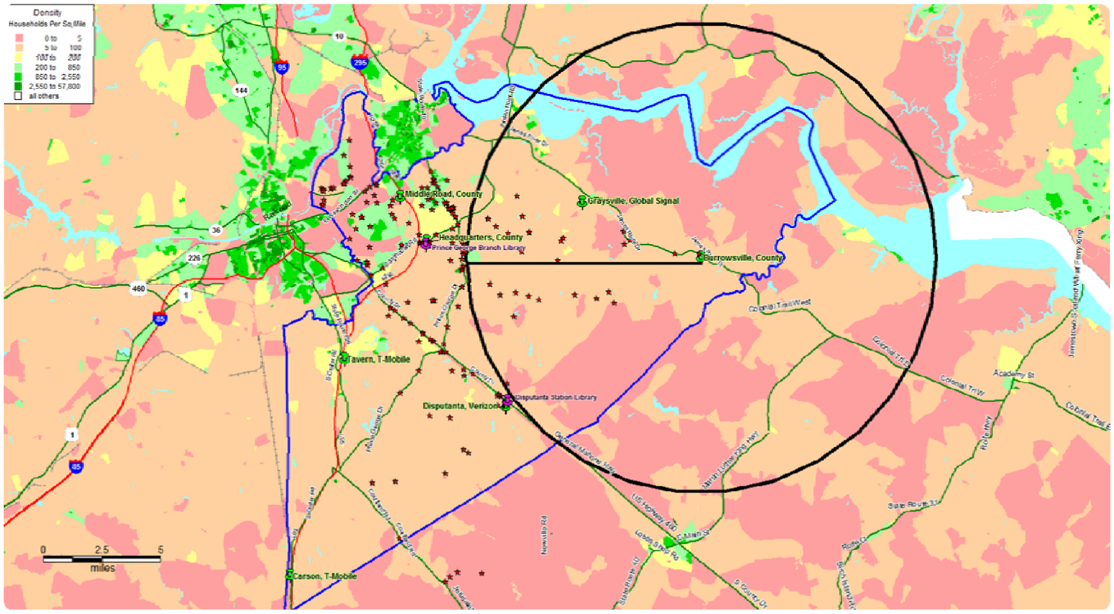


Tower Points
Libraries
Businesses

5.7GHz Motorola Canopy (5 mile radius)
2.4GHz Motorola Canopy (7.5 mile radius)
900MHz Motorola Canopy (10 mile radius)

Middle Road
View #1

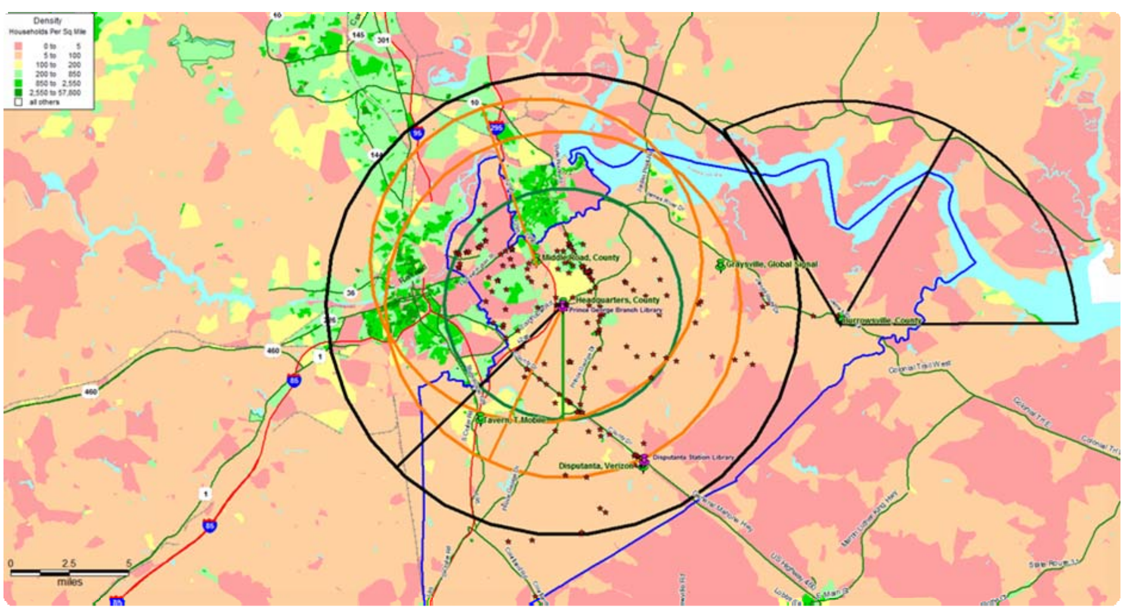
Prince George County, VA (full coverage)



Tower Points
Libraries
900MHz Motorola Canopy (10 mile radius)
Businesses

Burrowsville

Prince George County, VA – Scenario 1



Tower Points
Libraries
Businesses
5.7GHz Motorola Canopy (5 mile radius)
2.4GHz Motorola Canopy (7.5 mile radius)
900MHz Motorola Canopy (10 mile radius)

Middle Road Headquarters & Burrowsville

The

network is connected at customers by installing a receiving antenna at each customer. The customer antenna is unobtrusive and is about the size of a dinner plate. As discussed above, the customer antennas are dual purpose and are designed with mesh capabilities. Any customer who has line of sight to one of the three towers would be able to get coverage directly by a connection to the tower. However, there will be some customers without line of sight to a tower. In such a case, such customer only need see the antenna to another customer and the signal can be bounced from the one customer to another. However, also remember that the amount of bandwidth decreases by roughly half every time that bandwidth is shuttled from one customer antenna to another. Because of this, one would hope for a network where almost all customers get the signal with two bounces or less. Since Prince George is relatively flat and open, it appears that a large percentage of customers will have line of sight or will be within one hop of another customer.

K. Specific Brands Used in the Study

CCG is vendor neutral in that we have no ties to any equipment vendors. However, for purposes of the study we found it necessary to determine the cost of the network using specific vendors. The list of the vendors we chose for pricing the equipment for study purposes is as follows:

- For the backbone network radios CCG used Alcatel-Lucent radios. These radios have been in use for decades and are carrier class and very reliable. The other primary vendor for these radios is Harris-Stratex, who also has been making radios for many years. Both of these radios are SONET based. There is also a class of radios that uses Ethernet that could be used. Ethernet radio vendors include Bridgewave, Dragonwave, RAD, Solectek, Axxcelera, and Harris-Stratex. While Ethernet radios can deliver about the same amount of bandwidth as the radios used in the study they are not as reliable. Further, on a pure Ethernet ring there are issues of contention and packet priorities that don’t exist with SONET radios. Ethernet radios are best used as fiber extensions or to deliver a point-to-point route to a single customer. SONET radios are more suited to creating rings as is recommended in this design.
- For the point-to-multipoint radios on the towers that look at customers the study used Motorola. Other acceptable brands of radios include Trango Broadband and Tranzeo.
- For the customer receivers (access points) in the mesh network the study used Tropos. Other brands include Belair, Wavion or Motorola Hotzone.
- At each tower the study also used a MUX/DEMUX which allows the signal to be transferred from the mesh network to the backbone network. The study used a MUX from Interlink, but there are dozens of other brands of equipment that could serve the same purpose.

Most of this equipment can also be purchased from resellers or value added resellers (VARS).

In the study we used an overall discount of 25% from vendor list price for equipment. In the telecom industry nobody pays list price and the discount must be negotiated. It is possible that the County could negotiate a larger discount. If the County were able to get a 50% discount, there would be a savings of $1M for capital costs over the first three years.

III. Organization and Network Operations Options

A. Possible Organizational / Ownership Structures

CCG was tasked to look at alternate organizational and ownership structures in order to give the County the most alternatives to move forward. The approach taken in the study process was to first create a retail financial model. This shows the potential revenues, costs and profits from a network that was built and operated by one entity, be that the County or somebody else. From that model was created a second model referred to as the wholesale model that assumes that the County builds the network but that others operate the network.

1. Retail Network Alternatives

The retail model assumes that one entity builds, owns and operates the network. This model could be achieved with several ownership structures:

a. County-owned and Operated Network

One possible ownership structure is the County build the network and operate the broadband business. While this is possible under Virginia law, there are legal and regulatory barriers that would have to be overcome in order for the County to operate a retail broadband network. It is also CCG understands that the County would prefer to not operate the network, but this still has to be listed as an option.

One very important feature that would be necessary if the County were to operate the network is that within the County there would have to be a champion, that is an individual or group that was willing to tackle the complex task of launching and operating such a network. In our time in working with the County we didn't see any individuals or groups wanting to step into this role.

There is one key benefit of the County owning and operating the network that cannot be ignored. The County's biggest financial advantage is the ability to finance such a network through bonds. Bonds have interest rates and payment terms that allow for much lower annual debt payments than could be obtained by a commercial loan. As will be demonstrated in the financial discussion below, for this specific network it appears that bond financing will be needed to allow the venture to pay for itself.

b. Ownership by a Cooperative

Another ownership structure to consider is to use a Cooperative of some sort to own and operate the business. There are many cooperatives in the Country that operate utilities including electric cooperatives in and around the County.

A cooperative has advantages that make it an attractive alternative. First, a cooperative is owned by the members, making them vested in the success of the business. Second, the cooperative can potentially get financing terms that are almost as attractive as municipal bonds. For example, many cooperatives have borrowed money from the Rural Utility Service (RUS), which is a branch of the US Agriculture Department. The RUS was created to promote the creation of rural utilities and the RUS specifically has programs to promote the expansion of rural broadband. RUS interest rates and payment terms can be almost as attractive as bond financing.

It would be very hard to get a Cooperative to spring out of the woodworks, so to speak, and it would probably be necessary for the County to help get a Cooperative started if that is the chosen solution. A nearby example of a Cooperative started this way is in Wicomico County, Maryland where the County government seeded a Cooperative with about a $500,000 grant and then expected the Cooperative to raise the rest of the needed capital.

c. Ownership by a Non-profit Corporation

Another idea very similar to the Cooperative would be to operate the network with a non-profit corporation. There are subtle differences between the things that can be done by a Cooperative versus a non-profit corporation and a lawyer and tax expert would have to compare the two structures to see which one best fits the County.

d. Ownership by a Commercial Company

It is certainly possible that a commercial company could be lured to the County to build and operate a wireless network. However, the financial analysis done by CCG suggests fairly slim profit margins for such a business and it doesn’t appear to be a venture that would be considered by the typical commercial provider. There are commercial companies building wireless networks today, but they are typically concentrating on wealthier suburbs with customer densities greater than Prince George County. The biggest hurdle to jump for a commercial company is the cost of borrowing money, and a commercial firm would see far more stringent lending terms that would be seen from a County bond issue. The County should not completely abandon the idea of luring a commercial provider, but the CCG analysis shows the chance of success to be slim.

2. Wholesale Network Alternatives

The wholesale model assumes that the County builds the network but that somebody else operates it. There are several variations of this idea as follows:

One Operator Model

In a one operator model the County would build the network and would find one entity to operate the retail business. There are operating examples of this kind of structure. For example, several communities in Minnesota have constructed FTTH networks that are operated by Hiawatha Broadband, a commercial company.

There are two possible economic ways this model might operate. In the first version the County would build only the microwave backbone and the tower transmitters and the retail entity would pay for all of the customer receivers. In the second scenario the County would build all assets.

In this economic model the retail provider would compensate the County for using the County's network. If these 'access fees' are set properly, and if the network gets enough customers, then both the County and the retail operator will fare well financially. In the County's case the only goal would be to have enough revenue to maintain the network equipment and make bond payments. A retail operator would be able to add additional services like voice and security services to maximize their revenue opportunity on the network.

The biggest drawback of this, or any wholesale model, is that the County would be 100% reliant on the retail operator to succeed. Today there is no ready-made wholesale/retail type companies in the US, so there is no set of companies willing to jump in to be the retail providers. This means that the County would have to create a relationship with a company that has never done this before and then hope that the company can get enough customers to make the network pay for itself.

Open Access Model

The open access model is the same concept as the one retail provider model except that the County would open the door to multiple retail providers. Since this network is selling data connections this would be relatively simple. The County would have to add a fairly sophisticated router at the hub that would allow you to give each retail provider a way to identify his customers through techniques like Mac addresses.

The biggest problem with the open access network is that there is probably not enough revenue for any one provider to be very profitable. The open access model dilutes profitability for the service provider.

Again, the real problem is that there is no guarantee for the County that one or multiple service providers will sell to enough customers for the County to guarantee bond payments. There are two prominent examples of open access networks in the country – Provo, Utah and UTOPIA, a consortium of smaller towns in Utah. In both cases the networks have attracted two primary service providers. In both cases, press reports indicate that the networks are not making money and are being subsidized by the local governments. Service providers tend to cherry-pick - that is they get those customers that are easy to get instead of fighting to get every potential customer. Once a service provider has enough customers to have a positive margin they don't have enough incentive to get more customers.

B. The Financial Models

CCG undertook a study of the various ownership structures. There is a financial model that looks at the retail model. There was two different looks at the wholesale model – one where the County paid for all infrastructure and one where the County only paid for the base network. Following are the results of the financial analysis.

1. Comparing Retail versus Wholesale

In making a comparison of a retail and wholesale business, the difference is the functions that would be performed by the County versus those functions that would be performed by a different retail provider. CCG used the following table of wholesale versus retail functions to prepare the financial models. Note that the County (or some other organization) would perform every function in the retail model. The following two tables represent the role of each entity in the two different wholesale models. The retail provider is shown as an ISP in these tables.

Scenario 1	**County**	**ISP**
Build Backbone Network	x	
Build Base Stations	x	
Install CPE		x
Pay for CPE		x
Sales		x
Bill Customers		x
Pay for Internet Backbone		x
Employ Installers		x
Maintain the Core Network	x	
Own and Maintain Internet Routers		x
Operate Customer Help Desk		x

Scenario 2	**County**	**ISP**
Build Backbone Network	x	
Build Base Stations	x	
Install CPE		x
Pay for CPE	x	
Sales		x
Bill Customers		x
Pay for Internet Backbone		x
Employ Installers		x

Maintain the Core Network	x	
Own and Maintain Internet Routers		x
Operate Customer Help Desk		x

As can be seen, the primary difference between the two wholesale models is who pays for the customer receivers.

2. Common Assumptions

There are a number of assumptions that are common to all of the models, as follows:

a. Network

All of the financial models start with the wireless and fiber network as described earlier in this paper. This consists of a three site wireless backbone with dual redundant radios, transmitters using all three unlicensed frequencies, and a mesh network to get to customers. There is also fiber constructed to serve the business park. Finally, there is a fiber constructed to get access to cheaper Internet Backbone. The cost of the network is the same for all scenarios.

All models assume that the network would require one year for construction, with customers coming on board at the beginning of the second year.

The estimated cost of the core network is as follows:

	Years 1 - 3
Backbone Radios	$1,844,000
Point-to-Multipoint Radios	$1,752,000
Customer Receivers	$3,520,000
Fiber	$ 370,000
Fiber Electronics	$ 105,000
Inventory	$ 100,000
Total	$7,691,000

As noted above, CCG always uses conservatively high prices for equipment. The assumption was made that the County could get a 25% discount from list price for equipment, which is fairly standard in the industry. However, a purchase of this quantity of customer receivers would probably allow for a larger discount and could reduce the above capital by as much as $1M. The cost of the receiver at each customer's home is around $1,000. The model predicts this price will drop somewhat over time, the trend in the wireless industry.

b. Revenue

The model assumed a simple price structure for the retail products offered on the network. The assumption is that bandwidth on the network could be offered at prices similar to the prices charged today for DSL or cable modem.[8] Prices used in the models include:

$37.99 for residential broadband
$79.99 for small business broadband
$600 for a 10 Mbps connection to a large business.

The model also assumes a $100 service activation fee by customers to offset the cost of connection, for both the retail and wholesale models.

c. Expenses

The models assume that a staff of eight people is required to operate the business. This consists of a general manager, four initial installers (which reduces to two after a few years), three help desk / customer service reps to take order and handle customer issues. Accounting, billing and marketing are assumed done by outside vendors.

Another significant expense is the cost of the Internet backbone connection. There are two components necessary to determine Internet backbone costs. First is the concentration ratio. This is a ratio determined by the system operator that determines how much bandwidth to give customers during peak times. Commercial ISPs like the cable company use a concentration ratio of around 200 to 1. This means that they don't engineer for more than ½% of their customers to be downloading during a given second. This concentration ratio generally gives decent service, but during the peak evening hours the cable modem network often bogs down. This study assumes a concentration ratio of 150 to 1 which should allow for better service than the incumbent providers. The second important factor is the cost of the Internet Backbone. This study assumes that a fiber route will be constructed to reach a POP outside the County, to get cheaper rates. The model assumes rates of $100 per megabyte reducing to $80 per megabyte over time.

The models assume normal operating costs for such things as vehicles, computers, office space, etc., based upon the experience of clients of CCG.

d. Customers

In Phase 1 of this study CCG quantified the potential number of customers that might subscribe to a County broadband network. To cite from the Phase 1 Report:

> "CCG staff can translate these survey results into a projected residential market penetration. Today there are roughly 11,000 households in the County. These can be segregated by internet usage today as follows:

[8] See Appendix A for the existing data prices in the County

Uses DSL or cable modem	44%	4,840 households
Uses dial-up	35%	3,850 households
No Internet connection	22%	2,420 households

Using the above statistics the following potential broadband demand for a County network should exist:

Those with Broadband who would switch (40%)	1,936 households
Those with Dial-up who would switch (66%)	2,541 households
Those without Internet who would buy (38%)	920 households
Total Potential Residential Demand	5,397 households

To summarize, the residential survey results predict, according to residents' responses, that 5,397 households out of the total 11,000 households in the County would take broadband service from a County network. However, to be conservative, the CCG study assumed that only two of the three categories of residents would subscribe to the network. This includes 66% of those residents who still have dial-up today and 38% of residents those who have no Internet today. This totals 3,461 potential residential customers. The study did not assume that any customer using broadband today would switch to the new network. In addition to residents, the study also assumed that 200 businesses in the County would subscribe to the new network.

All three scenarios were analyzed using a base of 3,500 residential customers and 200 business customers by year three of operations. The studies then grow residential customers to 4,200 over ten years to account for growth of new homes in the County. CCG also then looked at a breakeven scenario for each option.

3. Results of the Retail Model

There are a few assumptions used in the retail model that don't apply necessarily to the wholesale model:

Bond Financing. The model assumes bond financing. It assumes a bond of $10.9M financed over 20 years at 6%. Obtaining cheap financing is essential to making the retail model successful. The model does not produce positive cash flow if it uses a standard commercial loan, which might have terms of a 10-year loan at 7.5%. The model assumes a set of standard bond terms and sizes the bond as follows:

Capital Construction	$ 7,934,876
Inventory	$ 100,000
Bond Fees	$ 400,000
5% Working Capital	$ 545,000
Capitalized Interest	$ 1,962,000
Total Bond	$10,941,876

The capital construction funds all of the needed assets, both the core network and the customer receivers.

Inventory represents the fact that the business will need to purchase and maintain a supply of customer receivers.

The bond assumes that interest is capitalized (pre-funded) during the three years required to install all of the customers.

Property Taxes. If the County was the system operator there would not need to be any payments of property taxes to the County. If the retail network was operated by a commercial company there would be property taxes.

There are two key figures to focus on in analyzing the financial results. First is EBITDA, which is defined as "earnings before interest, taxes, depreciation and amortization". EBITDA is the best measure of free cash generated by operations. Commercial firms always concentrate on EBITDA and set earnings goals based upon it.

The business plan assumes that the network would take one year to construct with customers coming on board at the start of the second year. The retail model becomes EBITDA positive by the beginning of the third year. This means that revenues exceed direct operating expenses by then.

Cash is extremely important in this business since the company must maintain a positive cash balance and also meet certain cash reserve standards set by the bondholders. Having sufficient cash reserves is more important to this business than many other businesses we have worked with since there is no fallback source of cash. Many other municipalities use their electric utilities or some other source of cash to provide a safety net for a starting this type of business, and the County does not have that luxury. This means that having adequate cash reserves must be a priority for this business. The business must perform to expectations or else face eventual cash shortfalls. However, if this business delivers good customer service and if there are sufficient customers, then this business should be perpetually self-sustaining and revenues should always exceed expenses.

Another way to measure financial success is by looking at net Income. Net income is total revenues minus total expenses. Net income is more important to mature companies than it is to start-up companies. By definition, almost every start-up company will have net income losses for a few years. This particular business plan happens to be capital intensive. One generally expects capital intensive firms to have negative net income in the early start-up years because of significant depreciation expense. Depreciation is an expense that is recognized to show the use of the assets over time. Depreciation tends to be highest in the early years, and thus has a significant effect on start-up profitability. This business does not become net income positive until the eighth year, although there is only a tiny loss for several years preceding that. Since the business is EBITDA positive it generates cash, but it would not have a book profit until the interest on the bonds shrinks over time.

Some key financial results of the retail business plan:

- Positive EBITDA in the middle of year two (the first year of getting customers)
- Positive net income in year 8.
- Total investment of just under $2,000 per customer
- Generates around $3.5M in cash over 10 years.
- Generates enough cash to cover operating expenses, capital requirements and bond payments.

The ten-year business plan results are included in Appendix B. This includes an Income Statement, a Statement of Cash Flows, and a Balance Sheet.

Breakeven Analysis. CCG analyzed the breakeven for the retail scenario. Breakeven in this case is defined as obtaining enough customers so that the business can always make bond payments and can always maintain a positive cash balance. This is the general minimum expectation of any municipal venture.

The base study was analyzed using 3,700 customers (3,500 residential customers and 200 business customers). CCG determined that the breakeven for the retail model is 2,750 customers (2,550 residential customers and 200 business customers). At that number of customers the business can make bond payments and maintain positive cash.

4. Results of the Wholesale Models

The wholesale model assumes that the County builds infrastructure but that some other entity is the retail provider that sells data services to customers.

CCG looked at two different wholesale scenarios:

- Scenario 1 where the County builds the base infrastructure at the towers and the retailer pays for the receivers at each customer's location.
- Scenario 2 where the County pays for all capital and the retailer pays a monthly lease to the County to pay for the network.

a. Wholesale Scenario 1

In this scenario the County would build the base network at the three towers and would look for a commercial partner to pay for the customer equipment and to operate the business. This partner is referred to in this study as the retail provider, or ISP.

This scenario is theoretically the most attractive to the County because it shares the financial burden of the venture with an outside commercial entity. Both sides need to make an investment to make this work.

The County would employ one technician to maintain the wireless network. All other employees would be employees of the retail provider.

Under a wholesale scenario, the retail provider must lease access from the County for use of the base network. The model assumed a monthly lease of $12 per customer for use of the network.

The County still requires a bond, although a smaller one since it is funding only the base network. The bond in this scenario would be as follows, still a 20-year bond at 6%:

Capital Construction	$4,163,688
Bond Fees	$ 180,000
5% Working Capital	$ 285,000
Capitalized Interest	$1,026,000
Total Bond	$5,654,688

Results of Scenario 1

This scenario does not work financially with 3,700 customers. At that level of customer penetration both the County and the ISP will lose cash each year.

CCG looked at the required breakeven penetration for this scenario and determined that the County could break even with 4,600 customers (4,400 residential customers and 200 business customers). With that many customers the County can make bond payments and will maintain a positive cash balance. With fewer customers the County would have an eventual cash shortfall.

While the County can reach breakeven at 4,600 customers, this scenario does not look attractive to the ISP partner. They must make an investment of $5.5M into the business and yet will see practically no return on their investment. It appears that the ISP will require significantly more than 4,600 customers in order to make this a profitable scenario. CCG's conclusion is that scenario 1 is not practical or achievable from the perspective of the ISP partner.

Why does the wholesale model perform poorly while the retail model is profitable? There are two reasons. The primary reason is that the financing terms for the private ISP would be far costlier than the cost of the County with bonds. In order to be profitable it appears that this business plan requires either bond financing, or commercial lending terms nearly as good as bond financing. Second, there are some additional expenses associated with having two operating companies involved in the process - an extra employee, extra accounting and legal costs, etc.

The ten-year business plan results of this scenario are included in Appendix B. This includes an Income Statement, a Statement of Cash Flows, and a Balance Sheet.

b. Wholesale Scenario 2

In this scenario the County would pay for all assets, both the equipment at the towers and the customer equipment.

This scenario is not as attractive to the County as Wholesale Scenario 2 since the County must take all of the financial risk.

The County would employ one technician to maintain the wireless network. All other employees would be employees of the retail provider.

Under a wholesale scenario, the retail provider must lease access from the County for use of the base network. Under scenario 2, the study assumes a monthly lease of $20.50 per customer charged to the ISP retailer.

The County still requires a bond, although a little smaller than the retail scenario bond. The bond in this scenario would be as follows, still a 20-year bond at 6%:

Capital Construction	$ 7,683,876
Inventory	$ 100,000
Bond Fees	$ 400,000
5% Working Capital	$ 535,000
Capitalized Interest	$ 1,926,000
Total Bond	$10,644,876

Results of Scenario 2

At 3,700 customers the County is able to make bond payments, but never builds up any significant cash reserves. The retail ISP just barely squeaks by on cash and any disruption of the business create a loss for the retail provider. Thus, 3.700 customers is the breakeven point for the County, but the retail ISP is going to want to get at least 4,200 customers to make a decent profit.

Scenario 2 could be either a one-retailer model or an open access model.

The primary issue with Scenario 2 is that the County still needs the ISP(s) to guarantee enough customers for the County to make bond payments. At less than 3,700 customers both the County and the ISP retailer would lose money.

The ten-year business plan results are included in Appendix B. This includes an Income Statement, a Statement of Cash Flows, and a Balance Sheet.

5. Summary of Results of Financial Analysis

The financial analysis demonstrates several things:

- First, it appears that a retail scenario can work financially. This would work if the County was the retail operator and funded the project with a bond. This could also work if the retail provider was another entity like a non-profit or a cooperative, as long as that entity could also get attractive financing terms somewhat equivalent to a bond. Even if such an entity could not get bond financing, there are financial scenarios that make the financing almost as attractive as bonds. For example, the County, State, or possibly other sources could fund part of the entity with grants, lowering the cost of financing. It's possible that customers might help fund a cooperative (other cooperatives have been funded in this manner). A more detailed discussion of financing options will be covered in the next section of this report.
- It does not appear that a wholesale partnership where the County funds the base network and a retailer funds the customer operation and equipment will work (Wholesale Scenario 1). This is the theoretically best wholesale option for the County since it shares the financial risk with both parties. However, since the business is marginal in terms of generated cash, this scenario does not work for the retail provider if they must get commercial funding instead of bond financing. The breakeven penetration for the retail provider looks to be greater than 5,000 customers, which is a tactical challenge. There would be a great risk in this scenario that the County would not be able to make bond payments. The results of this scenario could be improved if the retail partner was able to provide other services. For example, it's possible that the ISP could also provide some voice and security services. However, adding those services also adds costs and it's questionable if adding services makes the scenario viable.
- It appears that a wholesale partnership where the County builds all assets can breakeven for the County at around 3,700 customers (Wholesale Scenario 2). Under this scenario the County would build all wireless assets including the tower network and the customer receivers. The retail provider would fund the workforce. If the County charges $21.50 per month customer then bond payments can be made. However, the retail ISP makes no profits over ten years and just breaks even in terms of cash flow. This is not an attractive scenario for the typical ISP without a greater number of customers. This scenario can be looked at as a single provider model or as an open access model, since the results are the same regardless of how many providers are selling on the network. There are potentially ways to make this model better from the County perspective. For

example, if the retail ISPs were to contribute a lump sum of up-front cash the monthly rate could be lowered. If part of this network could be funded by grants the results would be better for both parties.

6. Could this be Done Cheaper?

One question worth asking is if the same results could be delivered with a less costly network? The network proposed by CCG involves a carrier class backbone. One way to save money would be to use a more traditional wireless backbone. Doing so would cut around $1.5M from the business plan. However, a cut in budget also means a cut in performance. The network as designed would be able to deliver real broadband to every customer. The design proposed by CCG could deliver a 3 Mbps connection to every potential wireless customer in the County. (Also note that the businesses in the Business Park would get much faster connections on fiber).

If the network was designed using normal unlicensed wireless backhaul (WiMax) then there would be significantly less bandwidth available to the customer side of the network. What would less bandwidth mean? First, the amount of bandwidth gotten by any customer would depend on how far they lived from one of the towers. Customers close to the towers could probably still get 3 Mbps, but customers further away would get less bandwidth. The network would also perform poorly under stress. For example, customer speeds would all decrease at peak hours, similar to a cable modem network. The network would also do poorly in bad weather and customers would lose speed when it rains or when wind is blowing the trees in their yard. Finally, some customers would not be able to get the service. With lower bandwidth the network could not reach customers on the fringe of the service area.

CCG's conclusion is that the County must consider a carrier class network if you are to construct this network. Anything else would result in poor performance that would greatly diminish the ability to get enough customers to pay for the network. This study recommends a microwave backhaul network, but also note that a fiber network between the towers would work, but at a greater cost.

7. A General Discussion of the Wholesale Business Model

The models prepared by CCG look at both a retail and two wholesale scenarios. Both wholesale models look to have a marginal chance of success, but there may be ways to make them look better financially. For example, getting grants would lower the financial risk.

However, the primary issue of concern with any wholesale model is the ability to get customers. In a retail model, the service provider is highly motivated to get enough customers to stay solvent and pay debt. However, the financial dynamics are different in a wholesale model. In the case where the County takes on most if not all of the financial risk, then the retail providers who would use the network have very little penalty for failure. With very little sunk costs in the project a retailer can walk away.

Further, a retail provider may not feel the need to push to get every customer. The retailer may be comfortable financially with some lower number of customers than what the County needs to meet bond payments. Basically, in a wholesale model there is an unavoidable conflict between the party with the most risk and the party making sales to customers.

There are few wholesale models operating in the US. The two primary ones are in Utah – iProvo and Utopia. iProvo is a municipal fiber-to-the-home venture serving the City of Provo, Utah. Utopia is a consortium of a number of small towns that have banded together to provide fiber-to-the-home. In both cases there are two primary retailers selling on these network. And in both cases the municipalities are having trouble making bond payments since the retailers have not sold as many customers as is needed to breakeven. The municipalities are essentially helpless in terms of making the retailers sell to more customers or to provide good enough customer service to keep customers.

It is a huge risk to build a network and then rely on an outside party to create success through sales.

The US does not have retailers waiting to provide service on a municipal network. This is not the case in Europe where there are a number of cities having success with open access networks. The primary difference between the US and Europe is the existence of real competition for telecom services. This is probably a factor of the recent joining of so many different cultures and companies in the European Union. The US instead has a duopoly system and in the vast majority of the Country telecommunications is provided by the duopoly of an incumbent telephone company and an incumbent cable company. These incumbents compete within their markets, but they have all silently agreed to not compete outside their markets. For example, iProvo would probably be quite successful if Comcast or one of the big cable companies agreed to compete using their network. However, in the US, the companies with the ability to provide this sort of competition stay on the sidelines.

This lack of competitive service providers is going to also present a challenge for the County should the County pursue a wholesale venture.

8 <u>Who Might be a Wholesale Partner?</u>

If the County wants to consider a wholesale model, who are the candidate companies that might become partners? The bad news is that there are no obvious partners, but there are a lot of potential partners. Following is a discussion of all of the potential partners and the likelihood of each wanting to provide data services on a County wireless network.

a. The Incumbent Service Providers

In an ideal world either Verizon or Comcast could provide service on a County network. Each company is currently one of the largest ISPs in the country in terms of serving data customers. So, is there any chance of one of the incumbents offering service on a County network? The short answer is no.

Both companies have established processes that are very specific to their own technologies. For example, Comcast has huge help desks to assist customers with cable modem issues and they are not equipped or willing to consider serving customers on any other technology platform. There is no evidence that either incumbent provider has ever joined a joint venture to serve customers off of their own networks.

b. Local Internet Service Providers (ISPs)

If this was ten years ago there would be a significant number of independent ISPs operating in Virginia. A number of these firms would have been interested in serving data customers on a County network. However, the last decade has been brutal on the independent ISP industry and most firms have merged with other companies or folded. The industry has undergone drastic changes due to the shrinking of dial-up services. Further, many ISPs tried to become CLECs (Competitive Local Exchange Carriers) and failed at the start of this decade when the Bell Companies were successful in thwarting competition.

CCG was unable to find any independent ISPs who are based in the County. There are several ISPs selling data in Petersburg and the area surrounding the County. Many of these ISPs are resellers of the incumbent data products meaning they will sell you DSL, ISDN or T1s from Verizon, but generally at a reduced price. The ISPs nearby to the County are generally considered as value added resellers rather than facility based ISPs. This means they generally use the networks and equipments of the incumbents rather than spend money on their own facilities. Ideally the County would want to partner with a facility-based ISP – that is one, who has the staff needed to install and visit customers, rather than one who only sells incumbent services. However, it's possible that some of these nearby ISPs might be a partner with the County if you build a network.

Some of the ISPs operating near to the County include such firms as Telecom Consulting Group, Internal Computer Service, Tech Plus, and Caliber Interworking Services. It is certainly possible to find a partner in this group. However, CCG believes that in order to find a facility-based partner that the County will need to issue and RFP and look at other potential partners than just these.

c. Independent Telephone Companies

Virginia has a number of independent telephone companies, that is, companies that are much smaller than Verizon. It's possible that one of these companies might want to compete using a County network. None of these companies operate within the County today, so one would have to be lured here. However, there are several partnerships across the country of municipalities and independent telephone companies. Most of these companies have been around for nearly a century and are generally very reliable partners.

d. National Service Providers

As discussed earlier, there are not really any national companies that are willing to compete using an open access network. Until recently there were a few companies willing to lease municipal wireless networks, most notable Earthlink. However, late last year they, and a few other companies like them, abandoned the business plan and there are no longer any companies looking at these ventures.

e. CLECs

CLECs are competitive telephone companies that compete with Verizon. There are several successful CLECs operating in Virginia. CLECs generally have one of two business plans. Some CLECs only provide services on facilities they build and own. Such CLECs generally also offer the triple play of voice, video and data. However, most CLECs offer service by leasing copper wires from Verizon.

In the business plan developed as part of this study, it was shown that the County could lease access to customers for $20.50 per month. CLECs should find this a competitive rate. Verizon sells access to customers using something called a UNE (Unbundled Network Element) Loop. A UNE Loop is a copper connection from a Verizon central office to a customer. The Verizon UNE Loop rates in Virginia are priced according to the size of the Verizon offices, with large city loop rates at $10.74, suburban loop rates at $16.45 and rural loop rates at $29.40. Prince George would be considered a rural area, so we can make a direct comparison between the $29.40 loops from Verizon and the $20.50 customer access offered by the County.

When a CLEC uses Verizon UNE Loops they incur additional costs above the loop rates. A CLEC must collocate, that is place equipment in the Verizon office. Further, a CLEC normally must spend money to put in DSL equipment in order to serve data to a customer. On the Prince George network a CLEC would have very few additional costs.

f. Electric Cooperatives

One last potential partner on the network might be an electric cooperative. The County is served today by the Prince George Electric Cooperative. Around the country there are a number of electric cooperatives that have gotten into the data business.

The biggest hurdle to working out a deal with Price George Electric Co-op is that they don’t serve the whole County. Customers in their electric service territory would already be members of the Cooperative, and the Co-op might consider bringing these customers data services. However, they will probably have some issues with serving customers in the rest of the County. However, the Co-op is a good candidate worth talking to as a potential partner.

In the end, there is no specific company, other than possibly Prince George Electric Cooperative, that might be an obvious partner for the County. How might the County find a potential partner? Other municipalities have found partners by issuing an RFP describing what they are looking for. To date, most municipal wireless RFPs seeking partners have been unsuccessful since most of these RFPs were looking for somebody to make an investment in a network. However, if the County is willing to fund the network as suggested by Wholesale Scenario 2, then there is a good chance that partners could be found with a well-written RFP.

9. What About Open Access?

The State of Virginia asked the County to consider an Open Access network in seeking solutions to the broadband gap. Wholesale scenario 2 is an option where the County would build all of the network and where one or more wholesalers would then sell access on the wireless network. This scenario would work equally well with one provider or with an open access system with multiple providers.

As cautioned earlier, all wholesale scenarios appear to be highly risky for the County. In all cases, it appears that any retail provider would need to sell to a lot of customers, around 3,500, in order to make this work for the County. The biggest risk in an open access network is that the County would build the network and then the retailers would not sell to enough customers. In such a case the County would be left with shortages in bond payments, and a situation with the need for a long-term subsidy of the network.

IV. Funding Strategies

This section looks at the possible ways to finance this venture should the County move forward.

A. Municipal Bonds

One potential source of financing is through the issuance of municipal tax-exempt bonds. Bonds have several features that make them very attractive for financing this sort of project. Bonds have a low interest rate. It's typical that a bond could have capitalized interest for this sort of project, meaning the burden of paying interest is relieved the first few years since the interest is pre-borrowed. Bonds also typically do not require any cash infusion by the County and would finance 100% of the business plan.

Bonds are the most likely funding source if the County decides to become the retail provider. Bonds would also be the funding vehicle choice for the core network under the various wholesale scenarios. It may be difficult or impossible to use bonds if the final solution is a Cooperative or non-profit operator.

There are a number of different types of bond financing that have been used by other municipalities to finance telecommunications networks:

Traditional Municipal Bonds

The most usual type of bond is a serial bond. These are bonds with a fixed principal repayment schedule, where principal is paid annually and an interest rate is applied to each maturity. The interest paid for serial bonds is dependent upon the credit worthiness of the County and with the perception of the bond-buying community of the project being financed. Bonds for these sorts of projects generally have repayment terms of 20 to 30 years. The most normal serial bonds would be secured by the general tax revenues of the County.

Revenue Bonds

Several municipalities have recently been able to get revenue bonds for telecommunications projects. Revenue bonds are bonds that are secured by only the revenue of the telecommunications project and which put no tax money at risk. The ability to get revenue bonds depends mostly upon having a good business plan that looks to spin off cash. In the case of this project, the scenario where the County is the retail provider looks to generate enough cash to be a candidate for revenue bonds.

Combination Construction Loan and Fixed-rate (Serial) Bonds

This project has a construction phase where the base network is constructed. This sort of venture would allow for a financing option where a first short-term construction loan or line of credit would be obtained to finance the construction. Then a second financing would be the issuance of long-term fixed-rate (serial) revenue bonds.

The advantage of this option is that it gives the County more of a window to time the bonds to get the best terms and interest rates. The bond market has been extremely volatile in the last year and this option extends the window during which the final bonds are sold.

Typically there are no payments due on the construction loan or line of credit until the construction loan or line of credit is taken out and repaid from bond proceeds. Included in the final bond proceeds would be enough capitalized interest to make the interest payments on the construction loan.

There are a number of places to get short-term construction loans including banks and the firms that fund bonds.

Variable rate demand obligations (VRDOs).

With a VRDO all principal is paid in a lump sum at maturity. However, the borrower has the right to redeem bonds in whole or in part at any time (upon an agreed upon notice). VRDOs are very effective in circumstances when the borrower wants to match the repayment of the bonds to a revenue stream that varies year to year or a revenue stream that can vary from initial estimates and changes over time. In the case of the new telecommunications system, this type of financing provides the flexibility to make bond payments that match the actual revenues received. If revenues are slower than anticipated principal payments do not need to be made. If revenues come in faster than anticipated repayment of the bonds can be accelerated without penalty.

VRDOs are most commonly structured as 7-day floating rate bonds. Interest rates are reset each week. Interest payments are made on the first day of each month. There is interest rate risk with VRDOs since the interest rate is reset each week. Unlike fixed-rate bonds the borrower does not know what the interest rate will be on the VRDOs over the life of the issue. Interest rates on VRDOs are on the short end of the yield curve and have therefore historically been lower than interest rates on fixed-rate bonds even with the additional ongoing costs for a liquidity provider and a remarketing agent. There is typically a maximum rate stated which the VRDOs cannot exceed.

The size of the borrowing for this project may make VRDOs a viable financing option. The legal structure and the financing participants of VRDOs make this type of issue significantly different than other types of borrowing. However, VRDOs are not an uncommon type of financing and the legal structure is very standardized and well known to the national credit rating agencies, such as Moody's Investors Service.

Capital appreciation (zero coupon) bonds (CABs)

CABs are bonds that are issued at a deep discount and which do not bear any stated interest rate. Like a Series E savings bond, CABs are bought at a price that implies a stated return calculated on a basis of the bond being payable at par at maturity. With no stated interest rate there is no interest paid until maturity, at which time all of the compounded accreted interest is paid. With no interest payments required in the beginning years of the bonds, this would enhance the cash flow in the beginning years of the business case model for the telecommunications system.

CABs do however have several drawbacks over other types of available financing. First, the interest rates on CABs are higher than both the fixed-rate and VRDOs. In today's market an additional 0.75% of yield is common for CABs. Second, investors prefer not to have a prepayment option on CABs, which limits the flexibility to call the bonds early if revenue collections are better than anticipated or if a restructuring of the debt is needed.

b. USDA Rural Development Rural Utilities Program (RDUP)

RDUP advertises that it has financing available for deployment of broadband and telecommunications services in rural communities. The loans can be used for the construction, improvement and acquisition of facilities and equipment for broadband service.

There are some factors that are positive for the County in regards to RDUP loans. These factors are as follows:

- The County is an eligible community to receive RDUP money.
- RDUP has significant money available to borrow to projects; enough to fully finance the wireless project.
- RDUP has attractive borrowing rates that would most likely be lower than conventional bank financing.

The RDUP application process is lengthy and the requirements are rigid. To date a municipality has never been the recipient of a RDUP loan, which based on the loan requirements, is not surprising. All loans have gone to commercial telecommunications companies. The RDUP requirements that raise concerns for the County project are as follows:

- The borrower must make a 20% equity contribution. The equity contribution does not need to be cash. In this case the equity would need to be more than $2,000,000.
- RDUP determines the number of years over which the loan must be repaid. This poses a risk to the County that the loan duration may be shorter than desired, which results in higher annual payments. A loan of less than 20 years will have a significant impact on the ability to repay the loan from revenues of the new telecommunications system.
- RDUP requires no more than one-year delay in the payment of principal on the loan and will not allow the borrower to capitalize interest on the loan to cover interest payments in the first few years. There is not sufficient cash flow in the first few years of the project to make principal and interest payments on the loan.
- There is a long time frame from the beginning the application process to the approval of the loan in Washington DC. It is anticipated that the entire process would take in

excess of twelve months. The application must include a market study, an engineering plan and a finance plan. This CCG study is a good beginning of all of these requirements, but there is additional work that would need to be done. For example, the market study cannot be more than six months old at the time the application is submitted and there would need to be another survey. The RDUP would probably require more vigorous engineering than was done by this study. In addition to the engineering work, the County would require the assistance of an outside consultant to complete the loan application process. The cost of a consultant to prepare the loan application and follow it through to the end would be approximately between $30,000 and $50,000. The County would incur the cost of the application process with no assurance the loan would be approved.

However, if the County were to consider the cooperative or non-profit structure, these loans might be a good alternative to seeking bonds.

As indicated above we have assumed that the County could finance such a venture entirely though a bond issue. Any financing plan should be designed to accomplish the following objectives:

- Establish a self-supporting business;
- Minimize debt service and related charges;
- Provide funds in the most cost-effective manner; and
- Conform to credit criteria established by rating agencies.

C. Funding a Cooperative

One of the most attractive options presented by this study, from a profitability standpoint, is to use a Cooperative or non-profit structure to operate the venture. First, a Cooperative would avoid all of the legal and regulatory issues that would apply if the County was the retail provider. Second, a cooperative or non-profit can be tax-free and can have many of the same characteristics as a municipal entity. However, funding a cooperative or non-profit has some challenges.

Over the years there have been a large number of cooperatives started around the country for electric and telecommunications projects. The County is very familiar with the electric cooperatives in the area. Generally cooperatives are formed to serve a need that is apparently of no interest to commercial providers – and the broadband gap in the County is exactly that sort of situation. It's clear that neither Verizon nor Comcast is going to fill the broadband gap.

A cooperative would be a new business and such a business would normally face significant hurdles in obtaining financing. Such firms generally cannot get traditional bank financing or else pay a significant premium for such loans.

If the County were to consider this structure, then several things need to happen:

- A cooperative or non-profit would need seed money to get started. This could be done with a grant from the County. This type of grant was recently done in Wicomico County

Maryland where the County government granted $500,000 as seed money for a broadband cooperative there.

- A cooperative would also need to get additional grant moneys from the State or federal government. It appears that the only way to make a cooperative work is by reducing the debt burden, and the only way to do that is to get at least some seed grant money.
- A cooperative has one additional source of revenue – deposits from customers. In looking back over the history of electric and telecommunications cooperatives, one of the initial sources of funding was to elicit money from potential customers / members. For example, a potential cooperative in this case could raise $875,000 in seed capital if it could get the 3,500 expected customers to make a $250 deposit into the cooperative. Since customers own a cooperative, such an investment would eventually be returned from profits.
- Assuming that a cooperative could raise the required 20% equity through grants and customer deposits, then they could get a loan from the RDUP. The terms of such a loan are nearly as good as bond financing.

Appendix A

Existing Data Prices in the County

There are three existing data providers in the County today. Following is a summary of the prices quoted by each existing provider:

Verizon

Verizon sells DSL to residential and business customers.

Verizon High Speed Internet for Home			
Plan Options	**Connection Speeds Up To…**	**Equipment**	**Monthly Price**
Starter Plan One year agreement	768 Kbps / 128 Kbps	Modem included	$17.99/mo.
Power Plan One year agreement	3.0 Mbps / 768 Kbps	Wireless router included	$29.99/mo.
Month-to-Month Plan No Commitment Required	3.0 Mbps / 768 Kbps	Modem included	$37.99/mo.

Verizon High Speed Internet for Business				
Maximum Connection Speed	**Up to 768Kbps / 128Kbps**	**Up to 3Mbps / 768Kbps**	**Up to 3Mbps / 768Kbps**	**Up to 3Mbps / 768Kbps**
Monthly Price	$29.99	$39.99	$59.99	$79.99
IP Address Type	Dynamic	Dynamic	Dynamic	Static

24/7 Business Grade Technical Support	Included	Included	Included	Included
E-Mail Accounts	10.net	10.net	10.net OR 3 domain name	10.net OR 3 domain name
Personal Web Space	Not Available	Not Available	20 MB	20 MB
Remote Dial-Up Access	Optional $8.95 for 50 hrs.	Optional $8.95 for 50 hrs.	Unlimited	Unlimited
Security Suite(1 PC)	Optional $4.95/mo.	Optional $4.95/mo.	Included	Included

Comcast

Comcast sells cable modem service to residents. Although they will quote no rates for businesses in the County, CCG believes there is a small number of businesses that have gotten Comcast cable modems.

Comcast Residential Internet Rates

	Performance	Performance Plus
Monthly Fee [1]	**$42.95**	**$52.95**
Monthly Fee [2]	**$56.97**	**$67.95**
Speeds	4Mbps / 384Kbps	6Mbps / 768Kbps
Modem Lease	$3	$3
Email Accounts	7	7
McAfee Security	Included	Included
24/7 Live Technical Support	Included	Included

1. Comcast High-Speed Internet with a subscription to Comcast Cable or Comcast Digital Voice.
2. Price for Comcast High-Speed Internet customers that do not subscribe to any other Comcast services.

HughesNet

HughesNet sells satellite data products in the County.

HughesNet Residential Service Plan Summary

	Home	Pro	ProPlus
Monthly Fee	**$59.99**	**$69.99**	**$79.99**
Max Upload Speeds	Up to 128 kbps	Up to 200 kbps	Up to 200 kbps
Max Download Speeds	Up to 700 kbps	Up to 1 Mbps	Up to 1.5 Mbps
Equipment	.74 m Antenna & 1 W Radio	.74 m Antenna & 1 W Radio	.74 m Antenna & 1 W Radio
Download Threshold	200 MB	375 MB	425 MB
Email Accounts	5	5	5
IP Address	Dynamic (NAT)	Dynamic (NAT)	Dynamic (NAT)
Email Defense (spam and anti-virus filtering)	Included	Included	Included
24/7 Live Technical Support	Included	Included	Included
Term Commitment	24 months	24 months	24 months
Limited Warranty	24 months	24 months	24 months

Equipment and Installation	$399.98

HughesNet Business Service Plan Summary

	Small Office		Business Internet
Monthly Fee	**$99.99**		**$179.99**
Upload Speeds	Up to 300 kbps		Up to 500 kbps
Download Speeds	Up to 1.5 Mbps		Up to 2 Mbps
Equipment	Satellite Modem, .98 m Antenna & 2 W Radio		Satellite Modem, .98 m Antenna & 2 W Radio
Download Threshold	500 MB		1,250 MB
Email Accounts	10		20
IP Address	Dynamic (NAT)		Dynamic (NAT)
Email Defense (spam and anti-virus filtering)	Included		Included
24/7 Live Technical Support	Included		Included
Term Commitment	24 months		24 months
Limited Warranty	24 months		24 months

Equipment and Installation	$699.98

Appendix B

Retail Model Income Statement

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Operating Revenue										
Data Revenue	0	418,984	1,380,027	1,909,244	1,968,030	2,007,236	2,046,897	2,087,471	2,128,956	2,171,353
Installation Revenue	0	180,000	196,000	36,100	30,300	32,300	34,200	36,300	38,400	40,800
Total Revenues	0	598,984	1,576,027	1,945,344	1,998,330	2,039,536	2,081,097	2,123,771	2,167,356	2,212,153
Interest on Working Cash Fund	357,000	187,000	94,000	64,000	70,000	79,000	89,000	102,000	116,000	132,000
Less Bad Debt:	0	11,979	31,521	38,907	39,967	40,791	41,622	42,475	43,347	44,243
Net Revenues	357,000	774,005	1,638,506	1,970,437	2,028,363	2,077,745	2,128,475	2,183,296	2,240,009	2,299,910
Operating Expenses										
Vehicle Expense	0	19,350	21,218	10,927	11,255	11,593	11,941	12,299	12,668	13,048
Tools & Equipment	0	3,780	4,080	2,061	2,081	2,102	2,123	2,144	2,166	2,187
Computer	650	4,836	5,092	4,589	4,727	4,869	5,015	5,165	5,217	5,269
Network Maintenance	23,333	315,713	337,357	281,327	288,867	296,633	304,632	312,871	321,357	330,098
Internet Transport	3,000	22,688	53,709	74,176	76,461	78,112	79,782	81,491	83,238	85,024
Advertising & Marketing	25,000	75,000	75,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Billing	0	27,858	91,459	126,397	130,303	133,027	135,783	138,602	141,485	144,431
Executive Expenses	43,750	90,125	92,829	95,614	98,482	101,436	104,480	107,614	110,842	114,168
General Accounting	12,000	17,364	17,981	18,625	19,294	19,989	20,710	21,459	22,237	23,045
Start-up Costs	150,000	0	0	0	0	0	0	0	0	0
Legal Expense	20,000	6,000	5,000	5,250	5,513	5,788	6,078	6,381	6,700	7,036
Other Gen & Admin	52,664	42,360	43,230	43,892	44,586	45,315	46,081	46,885	47,729	48,616
Total Operating Expenses	330,397	625,073	746,954	712,858	731,569	748,865	766,624	784,912	803,640	822,920
EBITDA	26,603	148,932	891,552	1,257,579	1,296,794	1,328,880	1,361,851	1,398,383	1,436,369	1,476,989
Cumulative EBITDA	26,603	175,535	1,067,087	2,324,666	3,621,460	4,950,340	6,312,191	7,710,575	9,146,944	10,623,933
Depreciation	112,154	498,778	776,078	792,200	802,890	814,523	815,408	789,979	799,937	796,235
Interest Expense	654,000	654,000	654,000	656,513	638,666	619,748	599,695	578,439	555,907	532,024
Net Income Before Taxes	(739,551)	(1,003,846)	(538,526)	(191,133)	(144,761)	(105,391)	(53,252)	29,966	80,525	148,730
Net Income	(739,551)	(1,003,846)	(538,526)	(191,133)	(144,761)	(105,391)	(53,252)	29,966	80,525	148,730
Cumulative Net Income	(739,551)	(1,743,397)	(2,281,923)	(2,473,057)	(2,617,818)	(2,723,209)	(2,776,460)	(2,746,495)	(2,665,970)	(2,517,240)

Retail Model Cash Flow Statement

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Cash Flow From Operations										
Net Income	(739,551)	(1,003,846)	(538,526)	(191,133)	(144,761)	(105,391)	(53,252)	29,966	80,525	148,730
Plus Depreciation and Amortization	112,154	498,778	776,078	792,200	802,890	814,523	815,408	789,979	799,937	796,235
Less Increase in Accounts Receivable	(24,000)	(67,963)	(44,579)	(27,661)	(4,827)	(4,115)	(4,228)	(4,568)	(4,726)	(4,992)
Plus Increase in Accounts Payable	46,741	10,542	4,963	(2,841)	1,559	1,441	1,480	1,524	1,561	1,607
Net Cash Provided by Operations:	(604,656)	(562,489)	197,936	570,564	654,861	706,459	759,409	816,900	877,296	941,580
Use of Cash from Investing Activities										
Inventory	(5,000)	(95,000)	0	0	0	0	0	0	0	0
Equipment	(4,226,688)	(1,872,792)	(1,835,397)	(169,917)	(104,597)	(163,741)	(106,446)	(107,119)	(106,977)	(113,377)
Total use of Cash from Investing	(4,231,688)	(1,967,792)	(1,835,397)	(169,917)	(104,597)	(163,741)	(106,446)	(107,119)	(106,977)	(113,377)
Cash Flows From Financing Activities										
Loans	10,941,876	0	0	0	0	0	0	0	0	0
Bond Fees	(400,000)									
Principal Repayment	0	0	0	(297,450)	(315,297)	(334,215)	(354,268)	(375,524)	(398,055)	(421,939)
Total Cash Flows from Financing Activities	10,541,876	0	0	(297,450)	(315,297)	(334,215)	(354,268)	(375,524)	(398,055)	(421,939)
Net Increase (Decrease) in Cash	5,705,533	(2,530,281)	(1,637,461)	103,197	234,966	208,503	298,695	334,257	372,264	406,265
Cash, beginning of period	0	5,705,533	3,175,252	1,537,791	1,640,988	1,875,954	2,084,457	2,383,152	2,717,409	3,089,673
Cash, end of period	5,705,533	3,175,252	1,537,791	1,640,988	1,875,954	2,084,457	2,383,152	2,717,409	3,089,673	3,495,938

Retail Model
Balance Sheet

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Assets										
Cash	5,705,533	3,175,252	1,537,791	1,640,988	1,875,954	2,084,457	2,383,152	2,717,409	3,089,673	3,495,938
Accounts Receivable	24,000	91,963	136,542	164,203	169,030	173,145	177,373	181,941	186,667	191,659
Inventory	5,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Vehicles	0	100,000	100,000	100,000	100,000	100,000	50,000	50,000	50,000	50,000
Tools and Work Equipment	50,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Furniture	25,000	27,000	27,000	27,000	27,000	32,000	32,000	32,000	32,000	37,000
Computers and Software	56,000	62,000	62,000	62,000	62,000	62,000	62,000	62,000	62,000	62,000
Internet Equipment	85,000	90,000	95,000	100,000	105,000	110,000	115,000	120,000	125,000	130,000
Wireless Backhaul Network	1,834,107	1,834,107	1,844,107	1,854,407	1,865,016	1,875,943	1,887,198	1,898,791	1,910,732	1,923,030
Wireless Base Stations	1,746,981	1,746,981	1,751,981	1,757,131	1,762,435	1,767,899	1,773,526	1,779,323	1,785,293	1,791,442
Wireless Equipment - CPE	0	1,724,792	3,520,189	3,655,956	3,736,940	3,819,389	3,901,353	3,983,683	4,065,349	4,147,878
Fiber Electronics	60,000	85,000	105,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000
Fiber	369,600	369,600	369,600	369,600	369,600	369,600	369,600	369,600	369,600	369,600
Capitalized Bond Fees	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Less Accumulated Depreciation	(112,154)	(610,932)	(1,387,010)	(2,170,510)	(2,970,700)	(3,730,323)	(4,493,131)	(5,280,710)	(6,078,247)	(6,872,082)
Total Assets	10,249,066	9,255,762	8,722,199	8,230,774	7,772,275	7,334,111	6,928,071	6,584,037	6,268,067	5,996,465
Liabilities										
Long Term Debt	10,941,876	10,941,876	10,941,876	10,644,426	10,329,129	9,994,914	9,640,646	9,265,123	8,867,067	8,445,129
Accounts Payable	46,741	57,283	62,246	59,405	60,964	62,405	63,885	65,409	66,970	68,577
Total Liabilities	10,988,618	10,999,159	11,004,122	10,703,831	10,390,093	10,057,320	9,704,532	9,330,532	8,934,037	8,513,705
Owners' Equity										
Retained Earnings	(739,551)	(1,743,397)	(2,281,923)	(2,473,057)	(2,617,818)	(2,723,209)	(2,776,460)	(2,746,495)	(2,665,970)	(2,517,240)
Total Owners' Equity	(739,551)	(1,743,397)	(2,281,923)	(2,473,057)	(2,617,818)	(2,723,209)	(2,776,460)	(2,746,495)	(2,665,970)	(2,517,240)

Wholesale Scenario 1
County
Income Statement

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
County Financial										
Operating Revenue										
Sell Network Access	0	208,936	684,126	944,640	973,914	995,070	1,016,472	1,038,366	1,060,752	1,083,630
Less Bad Debt:	0	0	0	0	0	0	0	0	0	0
Interest on Operating Cash	349,300	193,900	100,000	60,000	53,000	48,000	44,000	40,000	38,000	35,000
Net Revenues	349,300	402,836	784,126	1,004,640	1,026,914	1,043,070	1,060,472	1,078,366	1,098,752	1,118,630
Operating Expenses										
Vehicle Expense	3,336	5,160	5,305	5,464	5,628	5,796	5,970	6,149	6,334	6,524
Tools & Equipment	0	1,008	1,020	1,030	1,041	1,051	1,062	1,072	1,083	1,094
Rent and Maintenance	0	0	0	0	0	0	0	0	0	0
Computer	300	624	637	656	675	696	716	738	745	753
Network Maintenance	45,000	67,500	69,525	71,611	73,759	75,972	78,251	80,599	83,016	85,507
General Accounting	3,333	5,150	5,305	5,464	5,628	5,796	5,970	6,149	6,334	6,524
Start-up Costs	100,000	0	0	0	0	0	0	0	0	0
Legal Expense	20,000	6,000	5,000	5,250	5,513	5,788	6,078	6,381	6,700	7,036
Other Gen & Admin	26,332	21,180	21,615	21,946	22,293	22,658	23,041	23,443	23,865	24,308
Total Operating Expenses	198,301	106,622	108,406	111,420	114,536	117,757	121,088	124,531	128,078	131,745
EBITDA	150,999	296,214	675,720	893,220	912,378	925,313	939,384	953,835	970,674	986,885
Cumulative EBITDA	150,999	447,213	1,122,933	2,016,153	2,928,532	3,853,845	4,793,229	5,747,064	6,717,738	7,704,624
Depreciation	100,887	453,636	727,078	742,200	751,890	762,773	772,658	782,629	792,137	793,235
Interest Expense	642,000	642,000	642,000	638,693	621,330	602,926	583,417	562,738	540,818	517,583
Net Income Before Taxes	(591,888)	(799,422)	(693,358)	(487,672)	(460,842)	(440,386)	(416,691)	(391,532)	(362,281)	(323,933)
Net Income	(591,888)	(799,422)	(693,358)	(487,672)	(460,842)	(440,386)	(416,691)	(391,532)	(362,281)	(323,933)
Cumulative Net Income	(591,888)	(1,391,310)	(2,084,668)	(2,572,340)	(3,033,182)	(3,473,567)	(3,890,258)	(4,281,790)	(4,644,071)	(4,968,004)

Wholesale Scenario 1
County
Cash Flow Statement

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Cash Flow From Operations										
Net Income	(591,888)	(799,422)	(693,358)	(487,672)	(460,842)	(440,386)	(416,691)	(391,532)	(362,281)	(323,933)
Plus Depreciation and Amortization	100,887	453,636	727,078	742,200	751,890	762,773	772,658	782,629	792,137	793,235
Less Increase in Accounts Receivable	(23,200)	(23,001)	(19,143)	(18,376)	(1,856)	(1,346)	(1,450)	(1,491)	(1,699)	(1,657)
Plus Increase in Accounts Payable	19,925	(11,040)	149	251	260	268	278	287	296	306
Net Cash Provided by Operations:	(494,276)	(379,827)	14,726	236,403	289,452	321,309	354,795	389,893	428,453	467,951
Use of Cash from Investing Activities										
Inventory	(5,000)	(95,000)	0	0	0	0	0	0	0	0
Equipment	(4,093,688)	(1,759,792)	(1,830,397)	(163,717)	(101,397)	(128,841)	(100,846)	(99,719)	(99,577)	(103,977)
Total use of Cash from Investing	(4,098,688)	(1,854,792)	(1,830,397)	(163,717)	(101,397)	(128,841)	(100,846)	(99,719)	(99,577)	(103,977)
Cash Flows From Financing Activities										
Loans	10,644,876	0	0	0	0	0	0	0	0	0
Bond Fees	(400,000)	0								
Principal Repayment	0	0	0	(289,376)	(306,739)	(325,143)	(344,652)	(365,331)	(387,251)	(410,486)
Total Cash Flows from Financing Activities	10,244,876	0	0	(289,376)	(306,739)	(325,143)	(344,652)	(365,331)	(387,251)	(410,486)
Net Increase (Decrease) in Cash	5,651,912	(2,234,618)	(1,815,671)	(216,691)	(118,684)	(132,674)	(90,703)	(75,158)	(58,375)	(46,511)
Cash, beginning of period	0	5,651,912	3,417,294	1,601,623	1,384,932	1,266,248	1,133,574	1,042,870	967,713	909,338
Cash, end of period	5,651,912	3,417,294	1,601,623	1,384,932	1,266,248	1,133,574	1,042,870	967,713	909,338	862,827

Wholesale Scenario 1
County
Balance Sheet

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Assets										
Cash	5,651,912	3,417,294	1,601,623	1,384,932	1,266,248	1,133,574	1,042,870	967,713	909,338	862,827
Accounts Receivable	23,200	46,201	65,344	83,720	85,576	86,923	88,373	89,864	91,563	93,219
Inventory	5,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Vehicles	25,000	25,000	25,000	25,000	25,000	30,000	30,000	30,000	30,000	30,000
Tools and Work Equipment	50,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Furniture	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Computers and Software	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Wireless Backhaul Network	1,834,107	1,834,107	1,844,107	1,854,407	1,865,016	1,875,943	1,887,198	1,898,791	1,910,732	1,923,030
Wireless Base Stations	1,746,981	1,746,981	1,751,981	1,757,131	1,762,435	1,767,899	1,773,526	1,779,323	1,785,293	1,791,442
Wireless Equipment - CPE	0	1,724,792	3,520,189	3,655,956	3,736,940	3,819,389	3,901,353	3,983,683	4,065,349	4,147,878
Fiber Electronics	60,000	85,000	105,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000
Fiber	369,600	369,600	369,600	369,600	369,600	369,600	369,600	369,600	369,600	369,600
Capitalized Bond Fees	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Less Accumulated Depreciation	(100,887)	(554,523)	(1,281,601)	(2,016,301)	(2,763,691)	(3,501,464)	(4,272,122)	(5,054,751)	(5,846,888)	(6,637,123)
Total Assets	10,072,913	9,262,451	8,569,242	7,792,445	7,025,124	6,259,864	5,498,799	4,742,223	3,992,987	3,258,874
Liabilities										
Long Term Debt	10,644,876	10,644,876	10,644,876	10,355,500	10,048,761	9,723,618	9,378,966	9,013,635	8,626,385	8,215,899
Accounts Payable	19,925	8,885	9,034	9,285	9,545	9,813	10,091	10,378	10,673	10,979
Total Liabilities	10,664,801	10,653,761	10,653,910	10,364,785	10,058,306	9,733,431	9,389,057	9,024,013	8,637,058	8,226,878
Owners' Equity										
Paid-in Capital	0	0	0	0	0	0	0	0	0	0
Retained Earnings	(591,888)	(1,391,310)	(2,084,668)	(2,572,340)	(3,033,182)	(3,473,567)	(3,890,258)	(4,281,790)	(4,644,071)	(4,968,004)
Total Owners' Equity	(591,888)	(1,391,310)	(2,084,668)	(2,572,340)	(3,033,182)	(3,473,567)	(3,890,258)	(4,281,790)	(4,644,071)	(4,968,004)

Whole Scenario 1
Retail Provider
Income Statement

ISP Financial

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Operating Revenue										
Data Revenue	0	418,984	1,380,027	1,909,244	1,968,030	2,007,236	2,046,897	2,087,471	2,128,956	2,171,353
Installation Revenue	0	180,000	196,000	36,100	30,300	32,300	34,200	36,300	38,400	40,800
Total Revenues	0	598,984	1,576,027	1,945,344	1,998,330	2,039,536	2,081,097	2,123,771	2,167,356	2,212,153
Less Bad Debt:	0	11,979	31,521	38,907	39,967	40,791	41,622	42,475	43,347	44,243
Interest on Operating Cash	47,500	28,000	15,000	13,900	16,000	17,500	19,000	21,700	24,600	26,900
Net Revenues	47,500	615,005	1,559,506	1,920,337	1,974,363	2,016,245	2,058,475	2,102,996	2,148,609	2,194,810
Operating Expenses										
Buy Wholesale Access to County Network	0	208,936	684,126	944,640	973,914	995,070	1,016,472	1,038,366	1,060,752	1,083,630
Vehicle Expense	0	19,350	21,218	10,927	11,255	11,593	11,941	12,299	12,668	13,048
Tools & Equipment	0	3,780	4,080	2,061	2,081	2,102	2,123	2,144	2,166	2,187
Rent and Maintenance	26,250	45,000	45,000	46,350	47,741	49,173	50,648	52,167	53,732	55,344
Computer	650	4,836	5,092	4,589	4,727	4,869	5,015	5,165	5,217	5,269
Network Maintenance	23,333	315,713	337,357	281,327	288,867	296,633	304,632	312,871	321,357	330,098
Internet Transport	3,000	22,688	53,709	74,176	76,461	78,112	79,782	81,491	83,238	85,024
Advertising & Marketing	25,000	75,000	75,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Billing	0	27,858	91,459	126,397	130,303	133,027	135,783	138,602	141,485	144,431
Executive Expenses	43,750	90,125	92,829	95,614	98,482	101,436	104,480	107,614	110,842	114,168
General Accounting	12,000	17,364	17,981	18,625	19,294	19,989	20,710	21,459	22,237	23,045
Start-up Costs	100,000	0	0	0	0	0	0	0	0	0
Legal Expense	20,000	6,000	5,000	5,250	5,513	5,788	6,078	6,381	6,700	7,036
Other Gen & Admin	52,664	42,360	43,230	43,892	44,586	45,315	46,081	46,885	47,729	48,616
Property Tax	0	5,698	5,768	4,164	2,513	2,552	1,124	734	326	194
Total Operating Expenses	306,647	884,707	1,481,848	1,708,013	1,755,736	1,795,659	1,834,868	1,876,179	1,918,450	1,962,089
EBITDA	(259,147)	(269,702)	77,658	212,325	218,627	220,586	223,607	226,816	230,159	232,721
Cumulative EBITDA	(259,147)	(528,849)	(451,191)	(238,866)	(20,239)	200,346	423,954	650,770	880,929	1,113,650
Depreciation	16,067	57,622	62,050	63,650	65,250	67,600	59,200	24,400	25,000	20,800
Interest Expense	0	84,000	79,441	74,539	69,270	63,606	57,518	50,972	43,936	36,371
Net Income Before Taxes	(275,214)	(411,324)	(63,833)	74,135	84,106	89,379	106,890	151,444	161,223	175,550
Income Taxes	0	0	0	0	0	0	0	0	0	31,401
Net Income	(275,214)	(411,324)	(63,833)	74,135	84,106	89,379	106,890	151,444	161,223	144,149
Cumulative Net Income	(275,214)	(686,538)	(750,371)	(676,235)	(592,129)	(502,750)	(395,860)	(244,416)	(83,193)	60,956

Wholesale Scenario 1
Retail Provider
Cash Flow Statement

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Cash Flow From Operations										
Net Income	(275,214)	(411,324)	(63,833)	74,135	84,106	89,379	106,890	151,444	161,223	144,149
Plus Depreciation and Amortization	16,067	57,622	62,050	63,650	65,250	67,600	59,200	24,400	25,000	20,800
Less Increase in Accounts Receivable	(3,500)	(77,463)	(48,995)	(30,069)	(4,502)	(3,490)	(3,519)	(3,710)	(3,801)	(3,850)
Plus Increase in Accounts Payable	46,325	49,989	27,174	18,847	3,977	3,327	3,267	3,443	3,523	3,637
Net Cash Provided by Operations:	(216,323)	(381,176)	(23,605)	126,563	148,831	156,816	165,838	175,577	185,945	164,735
Use of Cash from Investing Activities										
Equipment	(206,000)	(113,000)	(9,000)	(10,200)	(10,200)	(68,900)	(11,600)	(11,400)	(11,400)	(16,400)
Total use of Cash from Investing	(206,000)	(113,000)	(9,000)	(10,200)	(10,200)	(68,900)	(11,600)	(11,400)	(11,400)	(16,400)
Cash Flows From Financing Activities										
Loans	1,120,000	0	0	0	0	0	0	0	0	0
Principal Repayment	0	(60,791)	(65,351)	(70,252)	(75,521)	(81,185)	(87,274)	(93,819)	(100,856)	(108,420)
Owners' Contribution	280,000	0	0	0	0	0	0	0	0	0
Total Cash Flows from Financing Activities	1,400,000	(60,791)	(65,351)	(70,252)	(75,521)	(81,185)	(87,274)	(93,819)	(100,856)	(108,420)
Net Increase (Decrease) in Cash	977,677	(554,967)	(97,955)	46,111	63,110	6,731	66,964	70,358	73,689	39,915
Cash, beginning of period	0	977,677	422,710	324,755	370,867	433,977	440,708	507,673	578,030	651,719
Cash, end of period	977,677	422,710	324,755	370,867	433,977	440,708	507,673	578,030	651,719	691,635

Wholesale Scenario 1
Retail Provider
Balance Sheet

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Assets										
Cash	977,677	422,710	324,755	370,867	433,977	440,708	507,673	578,030	651,719	691,635
Accounts Receivable	3,500	80,963	129,959	160,028	164,530	168,020	171,540	175,250	179,051	182,901
Vehicles	0	100,000	100,000	100,000	100,000	100,000	50,000	50,000	50,000	50,000
Tools and Work Equipment	40,000	40,000	44,000	48,000	52,000	56,000	60,000	64,000	68,000	72,000
Furniture	25,000	27,000	27,000	27,000	27,000	32,000	32,000	32,000	32,000	37,000
Computers and Software	56,000	62,000	62,000	62,000	62,000	62,000	62,000	62,000	62,000	62,000
Internet Equipment	85,000	90,000	95,000	100,000	105,000	110,000	115,000	120,000	125,000	130,000
Less Accumulated Depreciation	(16,067)	(73,689)	(135,739)	(198,189)	(262,239)	(274,939)	(281,539)	(303,539)	(326,139)	(344,539)
Total Assets	1,171,110	748,985	646,975	669,706	682,268	693,790	716,673	777,741	841,631	880,996
Liabilities										
Long Term Debt	1,120,000	1,059,209	993,858	923,607	848,086	766,901	679,628	585,808	484,953	376,533
Accounts Payable	46,325	96,314	123,487	142,334	146,311	149,638	152,906	156,348	159,871	163,507
Total Liabilities	1,166,325	1,155,523	1,117,346	1,065,941	994,397	916,539	832,533	742,157	644,824	540,041
Owners' Equity										
Paid-in Capital	280,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000	280,000
Retained Earnings	(275,214)	(686,538)	(750,371)	(676,235)	(592,129)	(502,750)	(395,860)	(244,416)	(83,193)	60,956
Total Owners' Equity	4,786	(406,538)	(470,371)	(396,235)	(312,129)	(222,750)	(115,860)	35,584	196,807	340,956

Wholesale Scenario 2
County
Income Statement

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
County Financial										
Operating Revenue										
Sell Network Access	0	122,304	400,464	552,960	570,096	582,480	595,008	607,824	620,928	634,320
Interest on Operating Cash	163,900	39,200	25,300	22,500	20,300	18,500	16,900	16,100	15,900	15,900
Net Revenues	163,900	161,504	425,764	575,460	590,396	600,980	611,908	623,924	636,828	650,220
Operating Expenses										
Vehicle Expense	3,336	5,160	5,305	5,464	5,628	5,796	5,970	6,149	6,334	6,524
Tools & Equipment	0	1,008	1,020	1,030	1,041	1,051	1,062	1,072	1,083	1,094
Computer	300	624	637	656	675	696	716	738	745	753
Network Maintenance	45,000	67,500	69,525	71,611	73,759	75,972	78,251	80,599	83,016	85,507
General Accounting	3,333	5,150	5,305	5,464	5,628	5,796	5,970	6,149	6,334	6,524
Start-up Costs	100,000	0	0	0	0	0	0	0	0	0
Legal Expense	20,000	6,000	5,000	5,250	5,513	5,788	6,078	6,381	6,700	7,036
Other Gen & Admin	26,332	21,180	21,615	21,946	22,293	22,658	23,041	23,443	23,865	24,308
Total Operating Expenses	198,301	106,622	108,406	111,420	114,536	117,757	121,088	124,531	128,078	131,745
EBITDA	(34,401)	54,882	317,358	464,040	475,860	483,223	490,820	499,393	508,750	518,475
Cumulative EBITDA	(34,401)	20,481	337,839	801,879	1,277,740	1,760,963	2,251,783	2,751,176	3,259,926	3,778,402
Depreciation	100,887	371,969	375,059	376,604	378,196	380,834	382,523	384,261	385,602	378,447
Interest Expense	342,000	342,000	342,000	339,281	330,058	320,281	309,918	298,933	287,289	274,946
Net Income Before Taxes	(477,288)	(659,087)	(399,701)	(251,845)	(232,394)	(217,892)	(201,621)	(183,802)	(164,141)	(134,918)
Net Income	(477,288)	(659,087)	(399,701)	(251,845)	(232,394)	(217,892)	(201,621)	(183,802)	(164,141)	(134,918)
Cumulative Net Income	(477,288)	(1,136,375)	(1,536,076)	(1,787,921)	(2,020,315)	(2,238,207)	(2,439,828)	(2,623,629)	(2,787,770)	(2,922,688)

Wholesale Scenario 2
County
Cash Flow Statement

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Cash Flow From Operations										
Net Income	(477,288)	(659,087)	(399,701)	(251,845)	(232,394)	(217,892)	(201,621)	(183,802)	(164,141)	(134,918)
Plus Depreciation and Amortization	100,887	371,969	375,059	376,604	378,196	380,834	382,523	384,261	385,602	378,447
Less Increase in Accounts Receivable	(6,800)	(15,232)	(13,448)	(12,475)	(1,245)	(882)	(911)	(1,001)	(1,075)	(1,116)
Plus Increase in Accounts Payable	19,925	(11,040)	149	251	260	268	278	287	296	306
Net Cash Provided by Operations:	(363,276)	(313,390)	(37,941)	112,536	144,817	162,328	180,269	199,745	220,681	242,719
Use of Cash from Investing Activities										
Equipment	(4,093,688)	(35,000)	(35,000)	(27,950)	(20,414)	(46,391)	(18,883)	(17,389)	(17,911)	(21,448)
Total use of Cash from Investing	(4,093,688)	(35,000)	(35,000)	(27,950)	(20,414)	(46,391)	(18,883)	(17,389)	(17,911)	(21,448)
Cash Flows From Financing Activities										
Bond	5,654,688	0	0	0	0	0	0	0	0	0
Bond Fees	(180,000)									
Principal Repayment	0	0	0	(153,720)	(162,943)	(172,720)	(183,083)	(194,068)	(205,712)	(218,055)
Total Cash Flows from Financing Activities	5,474,688	0	0	(153,720)	(162,943)	(172,720)	(183,083)	(194,068)	(205,712)	(218,055)
Net Increase (Decrease) in Cash	1,017,724	(348,390)	(72,941)	(69,135)	(38,540)	(56,783)	(21,697)	(11,712)	(2,942)	3,215
Cash, beginning of period	0	1,017,724	669,334	596,392	527,258	488,718	431,935	410,239	398,526	395,585
Cash, end of period	1,017,724	669,334	596,392	527,258	488,718	431,935	410,239	398,526	395,585	398,800

Wholesale Scenario 2
County
Balance Sheet

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Assets										
Cash	1,017,724	669,334	596,392	527,258	488,718	431,935	410,239	398,526	395,585	398,800
Accounts Receivable	6,800	22,032	35,480	47,955	49,200	50,082	50,992	51,994	53,069	54,185
Vehicles	25,000	25,000	25,000	25,000	25,000	30,000	30,000	30,000	30,000	30,000
Tools and Work Equipment	50,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Furniture	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Computers and Software	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Wireless Backhaul Network	1,834,107	1,834,107	1,844,107	1,854,407	1,865,016	1,875,943	1,887,198	1,898,791	1,910,732	1,923,030
Wireless Base Stations	1,746,981	1,746,981	1,751,981	1,757,131	1,762,435	1,767,899	1,773,526	1,779,323	1,785,293	1,791,442
Fiber Electronics	60,000	85,000	105,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000
Fiber	369,600	369,600	369,600	369,600	369,600	369,600	369,600	369,600	369,600	369,600
Capitalized Bond Fees	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000
Less Accumulated Depreciation	(100,887)	(472,856)	(847,915)	(1,217,019)	(1,590,715)	(1,946,549)	(2,327,072)	(2,711,333)	(3,096,935)	(3,472,382)
Total Assets	5,197,325	4,527,198	4,127,646	3,722,332	3,327,254	2,936,910	2,552,484	2,174,901	1,805,343	1,452,676
Liabilities										
Long Term Debt	5,654,688	5,654,688	5,654,688	5,500,968	5,338,024	5,165,304	4,982,221	4,788,153	4,582,440	4,364,385
Accounts Payable	19,925	8,885	9,034	9,285	9,545	9,813	10,091	10,378	10,673	10,979
Total Liabilities	5,674,613	5,663,573	5,663,721	5,510,252	5,347,569	5,175,117	4,992,312	4,798,530	4,593,114	4,375,364
Owners' Equity										
Retained Earnings	(477,288)	(1,136,375)	(1,536,076)	(1,787,921)	(2,020,315)	(2,238,207)	(2,439,828)	(2,623,629)	(2,787,770)	(2,922,688)
Total Owners' Equity	(477,288)	(1,136,375)	(1,536,076)	(1,787,921)	(2,020,315)	(2,238,207)	(2,439,828)	(2,623,629)	(2,787,770)	(2,922,688)

Wholesale Scenario 2
Retail Provider
Income Statement

ISP Financial

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Operating Revenue										
Data Revenue	0	418,984	1,380,027	1,909,244	1,968,030	2,007,236	2,046,897	2,087,471	2,128,956	2,171,353
Installation Revenue	0	180,000	196,000	36,100	30,300	32,300	34,200	36,300	38,400	40,800
Total Revenues	0	598,984	1,576,027	1,945,344	1,998,330	2,039,536	2,081,097	2,123,771	2,167,356	2,212,153
Less Bad Debt:	0	11,979	31,521	38,907	39,967	40,791	41,622	42,475	43,347	44,243
Interest on Working Cash	32,100	152,200	75,000	30,000	24,000	18,000	14,000	11,000	8,000	7,000
Net Revenues	32,100	739,205	1,619,506	1,936,437	1,982,363	2,016,745	2,053,475	2,092,296	2,132,009	2,174,910
Operating Expenses										
Buy Wholesale Access to County Network	0	122,304	400,464	552,960	570,096	582,480	595,008	607,824	620,928	634,320
Vehicle Expense	0	19,350	21,218	10,927	11,255	11,593	11,941	12,299	12,668	13,048
Tools & Equipment	0	3,780	4,080	2,061	2,081	2,102	2,123	2,144	2,166	2,187
Rent and Maintenance	26,250	45,000	45,000	46,350	47,741	49,173	50,648	52,167	53,732	55,344
Computer	650	4,836	5,092	4,589	4,727	4,869	5,015	5,165	5,217	5,269
Network Maintenance	23,333	315,713	337,357	281,327	288,867	296,633	304,632	312,871	321,357	330,098
Internet Transport	3,000	22,688	53,709	74,176	76,461	78,112	79,782	81,491	83,238	85,024
Advertising & Marketing	25,000	75,000	75,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Billing	0	27,858	91,459	126,397	130,303	133,027	135,783	138,602	141,485	144,431
Executive Expenses	43,750	90,125	92,829	95,614	98,482	101,436	104,480	107,614	110,842	114,168
General Accounting	12,000	17,364	17,981	18,625	19,294	19,989	20,710	21,459	22,237	23,045
Start-up Costs	100,000	0	0	0	0	0	0	0	0	0
Legal Expense	20,000	6,000	5,000	5,250	5,513	5,788	6,078	6,381	6,700	7,036
Other Gen & Admin	52,664	42,360	43,230	43,892	44,586	45,315	46,081	46,885	47,729	48,616
Property Tax	0	5,698	98,363	89,865	79,432	70,486	59,813	49,942	39,788	29,688
Total Operating Expenses	306,647	798,075	1,290,781	1,402,033	1,428,837	1,451,003	1,472,093	1,494,845	1,518,088	1,542,273
EBITDA	(274,547)	(58,870)	328,725	534,405	553,526	565,741	581,382	597,450	613,921	632,637
Cumulative EBITDA	(274,547)	(333,417)	(4,692)	529,712	1,083,238	1,648,980	2,230,362	2,827,812	3,441,733	4,074,370
Depreciation	16,067	139,289	414,069	429,246	438,944	449,539	449,335	422,768	431,535	435,588
Interest Expense	0	60,000	326,743	308,587	289,070	268,088	245,533	221,287	195,221	167,201
Net Income Before Taxes	(290,614)	(258,159)	(412,087)	(203,429)	(174,488)	(151,886)	(113,486)	(46,604)	(12,835)	29,848
Net Income	(290,614)	(258,159)	(412,087)	(203,429)	(174,488)	(151,886)	(113,486)	(46,604)	(12,835)	29,848
Cumulative Net Income	(290,614)	(548,773)	(960,861)	(1,164,289)	(1,338,777)	(1,490,663)	(1,604,149)	(1,650,753)	(1,663,589)	(1,633,741)

Wholesale Scenario 2
Retail Provider
Cash Flow Statement

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Cash Flow From Operations										
Net Income	(290,614)	(258,159)	(412,087)	(203,429)	(174,488)	(151,886)	(113,486)	(46,604)	(12,835)	29,848
Plus Depreciation and Amortization	16,067	139,289	414,069	429,246	438,944	449,539	449,335	422,768	431,535	435,588
Less Increase in Accounts Receivable	(2,100)	(87,663)	(45,195)	(26,411)	(3,827)	(2,865)	(3,061)	(3,235)	(3,309)	(3,575)
Plus Increase in Accounts Payable	46,325	35,361	25,880	9,271	2,234	1,847	1,757	1,896	1,937	2,015
Net Cash Provided by Operations:	(230,323)	(171,173)	(17,334)	208,677	262,863	296,635	334,546	374,825	417,327	463,876
Use of Cash from Investing Activities										
Inventory	(5,000)	(95,000)	0	0	0	0	0	0	0	0
Equipment	(206,000)	(1,837,792)	(1,804,397)	(145,967)	(91,184)	(151,350)	(93,564)	(93,730)	(93,066)	(98,929)
Total use of Cash from Investing	(211,000)	(1,932,792)	(1,804,397)	(145,967)	(91,184)	(151,350)	(93,564)	(93,730)	(93,066)	(98,929)
Cash Flows From Financing Activities										
Loans	800,000	3,600,000	0	0	0	0	0	0	0	0
Principal Repayment	0	(43,422)	(242,079)	(260,235)	(279,753)	(300,734)	(323,289)	(347,536)	(373,601)	(401,621)
Owners' Contribution	200,000	900,000	0	0	0	0	0	0	0	0
Total Cash Flows from Financing Activities	1,000,000	4,456,578	(242,079)	(260,235)	(279,753)	(300,734)	(323,289)	(347,536)	(373,601)	(401,621)
Net Increase (Decrease) in Cash	558,677	2,352,614	(2,063,810)	(197,525)	(108,074)	(155,449)	(82,307)	(66,441)	(49,340)	(36,674)
Cash, beginning of period	0	558,677	2,911,291	847,481	649,956	541,882	386,433	304,126	237,685	188,344
Cash, end of period	558,677	2,911,291	847,481	649,956	541,882	386,433	304,126	237,685	188,344	151,670

Wholesale Scenario 2
Retail Provider
Balance Sheet

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Assets										
Cash	558,677	2,911,291	847,481	649,956	541,882	386,433	304,126	237,685	188,344	151,670
Accounts Receivable	2,100	89,763	134,959	161,370	165,197	168,062	171,123	174,358	177,667	181,242
Inventory	5,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Vehicles	0	100,000	100,000	100,000	100,000	100,000	50,000	50,000	50,000	50,000
Tools and Work Equipment	40,000	40,000	44,000	48,000	52,000	56,000	60,000	64,000	68,000	72,000
Furniture	25,000	27,000	27,000	27,000	27,000	32,000	32,000	32,000	32,000	37,000
Computers and Software	56,000	62,000	62,000	62,000	62,000	62,000	62,000	62,000	62,000	62,000
Internet Equipment	85,000	90,000	95,000	100,000	105,000	110,000	115,000	120,000	125,000	130,000
Wireless Equipment - CPE	0	1,724,792	3,520,189	3,655,956	3,736,940	3,819,389	3,901,353	3,983,683	4,065,349	4,147,878
Less Accumulated Depreciation	(16,067)	(155,356)	(569,425)	(997,471)	(1,435,215)	(1,829,854)	(2,226,589)	(2,646,957)	(3,076,092)	(3,509,280)
Total Assets	755,710	4,989,490	4,361,203	3,906,810	3,454,803	3,004,031	2,569,013	2,176,769	1,792,269	1,422,511
Liabilities										
Long Term Debt	800,000	4,356,578	4,114,499	3,854,264	3,574,511	3,273,777	2,950,488	2,602,952	2,229,351	1,827,729
Accounts Payable	46,325	81,685	107,565	116,836	119,070	120,917	122,674	124,570	126,507	128,523
Total Liabilities	846,325	4,438,263	4,222,064	3,971,100	3,693,581	3,394,694	3,073,162	2,727,522	2,355,858	1,956,252
Owners' Equity										
Paid-in Capital	200,000	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000	1,100,000
Retained Earnings	(290,614)	(548,773)	(960,861)	(1,164,289)	(1,338,777)	(1,490,663)	(1,604,149)	(1,650,753)	(1,663,589)	(1,633,741)
Total Owners' Equity	(90,614)	551,227	139,139	(64,289)	(238,777)	(390,663)	(504,149)	(550,753)	(563,589)	(533,741)